U. S. DEPARTMENT OF AGRICULTURE.
BUREAU OF PLANT INDUSTRY—BULLETIN NO. 160.
B. T. GALLOWAY, *Chief of Bureau.*

ITALIAN LEMONS AND THEIR BY-PRODUCTS.

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I.—THE ITALIAN LEMON INDUSTRY.

BY
G. HAROLD POWELL,
POMOLOGIST IN CHARGE OF FRUIT TRANSPORTATION AND STORAGE INVESTIGATIONS.

II.—THE BY-PRODUCTS OF THE LEMON IN ITALY.

BY
E. M. CHACE,
ASSISTANT CHIEF OF THE DIVISION OF FOODS, BUREAU OF CHEMISTRY.

ISSUED OCTOBER 6, 1909.

WASHINGTON:
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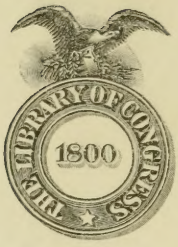

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., June 17, 1909.

Sir: I have the honor to transmit herewith a manuscript entitled "Italian Lemons and Their By-Products," consisting of two papers, "The Italian Lemon Industry" and "The By-Products of the Lemon in Italy," and to recommend that it be published as Bulletin No. 160 of the Bureau series. These papers have been prepared by Mr. G. Harold Powell, Pomologist in Charge of Fruit Transportation and Storage Investigations, Bureau of Plant Industry, and by Mr. E. M. Chace, Assistant Chief of the Division of Foods, Bureau of Chemistry, with a view to publication.

The observations summarized in the first manuscript were made by Mr. Powell, who went to Italy in the fall of 1908 to study the methods used in the development of the lemon industry. During the trip through Sicily he was accompanied by Dr. Arthur S. Cheney, American consul at Messina, who was killed in the earthquake in December, who rendered the greatest service to the Department of Agriculture on this trip on account of his familiarity with the lemon industry and with the people. The paper on "The By-Products of the Lemon in Italy" was prepared by Mr. Chace, who investigated these products, especially the oil of lemon, in Sicily in 1908 for the Bureau of Chemistry. The Bureau of Chemistry also received much assistance from Doctor Cheney in connection with its work.

The lemon industry is increasing rapidly in the United States. The crop in California now amounts to from one-third to two-fifths of the total quantity used in the United States. The remainder of the supply is imported chiefly from Italy. The by-product business has not yet assumed commercial importance in California, but there is an increasing interest developing in this branch of the industry.

The observations made in this bulletin should be helpful to the American lemon industry in showing the status of the industry in Italy and the methods used in growing, marketing, and distributing the crop.

Respectfully,

B. T. Galloway,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

CONTENTS.

	Page.
I.—The Italian lemon industry	7
Introduction	7
The extent and location of the Italian lemon industry	7
The commercial importance of the Italian lemon industry	10
The exports of lemons from Italy	11
The imports of lemons into the United States	11
The districts from which Italian lemons are exported to the United States	12
The distribution of foreign lemons in the United States	13
The methods of handling foreign lemons in the United States	13
Methods of securing the lemons	13
Methods used in selling the lemons	14
The exports of lemon by-products from Italy	15
The exports of citrate of lime	15
The imports of citrate of lime into the United States	16
The exports of essential oils from citrus fruits	16
The imports of lemon oil into the United States	17
The exports of concentrated lemon and citron juice	17
The exports of raw citron and lemon juice	18
The exports of lemon, orange, and other citrus-fruit peel	18
The rates of duty on lemons and their by-products entering the United States	19
The season of lemon ripening in Italy	20
The character of the lemons in different regions of Italy	21
The character of the lemons exported to different markets	21
Terms applied to lemons ripening at different periods	22
The Verdelli lemons	22
Method of production	23
The lemon groves or gardens of Italy	23
Handling the lemon garden	24
Propagation	24
Pruning	25
Tillage	25
Fertilizing	25
Irrigation	26
Protection against frost	27
Handling the lemon crop	28
Selling the fruit	28
Methods used in the gardens	30
Methods used in the packing houses	31
The cost of producing lemons in Italy	32

Page.
II.—The by-products of the lemon in Italy 35
Introduction 35
Geographical distribution of the by-product industry 35
The industry in the Etna district 36
The industry in the Messina district 38
The industry in the Palermo district 40
The industry in the Syracuse district 41
The industry in the north-coast towns 42
Manufacture of by-products 43
Equipment of by-product factories 44
Preparation of the fruit 44
Extraction of the essential oil 45
Treatment of the residues 47
Machine-made essential oil 48
Citrate of lime 49
Cost of production of by-products 50
Description of plates 52
Index 53

ILLUSTRATIONS.

PLATES.

Page.
PLATE I. Lemon groves on the Amalfi coast. Fig. 1.—Terraces on the mountain side. Fig. 2.—Terraces rising from the sea 52
II. An Italian and an American lemon grove compared. Fig. 1.—A grove at Mascali, Sicily, showing a distributing furrow and basins around the trees. Fig. 2.—A grove of low-headed trees in California 52
III. A lemon-picking scene and a packing-house interior. Fig. 1.—Picking and grading the fruit, Palermo. Fig. 2.—Interior of a packing house, Catania 52
IV. Preparation of citrate of lime. Fig. 1.—A crushing machine. Fig. 2.—A lemon-juice press 52
V. Preparation of lemon oil. Fig. 1.—Paring lemons, 3-piece method, Palermo. Fig. 2.—Interior of lemon by-product factory, Syracuse. 52
VI. Lemon-oil machinery. Fig. 1.—A lemon-oil machine used in Calabria. Fig. 2.—Disks used in Calabrian machines 52

TEXT FIGURES.

FIG. 1. Map of Italy and adjacent countries 9
2. A trellis over a lemon grove 28
3. Lemon trees growing under a trellis 29
4. Map of Sicily, showing the regions where lemon by-products are prepared 36
5. A lemon-oil still used on residues, Palermo 47

B. P. I.—493.

ITALIAN LEMONS AND THEIR BY-PRODUCTS.

I.—THE ITALIAN LEMON INDUSTRY.

By G. Harold Powell, *Pomologist in Charge of Fruit Transportation and Storage Investigations.*

INTRODUCTION.

The lemon is grown in nearly all parts of Italy, from the provinces of Lombardy and Venetia on the north to the island of Sicily on the south. The distinction acquired by Italy as the lemon-growing center of the world is due principally to the fruit and by-products from the groves in the southern Mediterranean region, especially on the Sorrentine peninsula, across the bay from Naples, in the province of Calabria, and in Sicily. There are few parts of the world where horticulture has been more highly developed, where the products enter more widely into commerce, and where, on the whole, an industry has thrived more and has contributed to the welfare of a greater number of people.

In the provinces of the northern and the central part of the country the climatic conditions preclude the development of an extensive commercial lemon culture. Though a comparatively large industry was developed there in the past, lemon culture has been on the decline during the last decade in this part of Italy. The trees suffer too often from frost, from high winds, and from driving rains, predisposing them to disease and making lemon growing there a precarious undertaking. In southern Italy and in Sicily the climate is milder and more like that of southern California. The number of lemon trees in that part of Italy is at least fifteen times the number in California.

THE EXTENT AND LOCATION OF THE ITALIAN LEMON INDUSTRY.

It is difficult to obtain exact statistical information on the lemon industry of Italy. In 1904 there were about 17,000,000 citrus-fruit trees of all kinds in Italy, at least 8,000,000 of which are said to be lemons. Probably three-fourths or more of the lemon trees are located in Sicily. In 1898 there were over 6,000,000 lemon trees in

Sicily. The next most extensive regions are Reggio di Calabria and the Sorrentine peninsula, both on the mainland, the former having about a million trees and the latter 500,000 or more.

On the Sorrentine peninsula the most extensive groves, or gardens as they are called in Italy, are located on the Amalfi coast, at Majori, Minori, Amalfi, and to a smaller extent at other places from Cetra to Positana. The trees are planted on walled terraces on the mountain sides that rise abruptly from the Gulf of Salerno, as shown in Plate I, figures 1 and 2. The trees are covered with straw mats placed on trellises late in the fall, to protect them from frost during the winter months. There are many groves also on the side of the Bay of Naples in the vicinity of Sorrento, and other plantings in the vicinity of Naples, the trees in the Naples district in 1898 numbering 180,000. There are also many groves in the vicinity of Cosenza and Catanzaro and at Reggio, in the province of Calabria, the by-product industry having reached the highest development in the latter district. A map of Italy and adjacent countries is shown in figure 1.

Sicily is the heart of the lemon industry of the world. The groves are located near the coast along the northern and eastern sides of the triangular island, usually in a narrow strip, but sometimes extending inland into the fertile valleys and up the slopes of the hills and mountains a thousand feet or more in elevation. The groves are locally distinguished as the upland and the valley, or lowland, groves, though the term "upland groves" is often applied to trees planted on heavier soils irrespective of altitude and the term "lowland groves" to trees planted on lighter soils. On the north coast of Sicily the groves extend from Messina to Palermo somewhat irregularly, with a distinct break between Termini and Santo Stefano, where the mountains reach the sea, and beyond Palermo to a limited extent to Trapani. The principal lemon-growing center between Messina and Santo Stefano is Barcelona, with smaller centers around Bauso, Naso, Santa Agata di Miletello, and other smaller places. Near Palermo the most important districts on the coast are Bagheria and Ficarazzi. On the eastern coast there is an almost continuous narrow ribbon of groves close to the Strait of Messina, with inland valleys, like the Alcantara, reaching from Messina to Catania. In the Catania region, located on the lava beds of Mount Etna, the most important districts are Acireale, Giarre, Mascali, and Fiumefreddo. In the district extending northeast beyond Giardini the gardens are almost unbroken to Messina, the most important districts lying around Letojanni, Santa Teresa, Roccalumera, Galati, Tremestieri, and Gazzi, with Messina as the center from which the fruit and by-products are shipped. There is another district on the southeast coast around Syracuse, extending from Augusta to Avola, where it

is less mountainous than in other parts of the island and where the industry is farther inland. Syracuse is the most important center of this region. The industry is developed most extensively in the province of Palermo, in which is located the Conco d'Oro, or the Place of Gold. This beautiful valley extends inland from Palermo

FIG. 1.—Map of Italy and adjacent countries.

to Monreale and is planted with several thousand acres of lemon groves and other fruits. Hardly second in the extent of the industry are the provinces of Messina and of Catania, with the provinces of Syracuse, Trapani, Caltanissetta, and Girgenti, mentioned in the order of their importance, containing fewer trees.

The fresh fruit export industry centers in the province of Palermo, with the city of Palermo as the port of export. Before the earthquake in December, 1908, Messina was the center of the lemon oil, citrate of lime, and other citrus by-product industries. There was some fresh fruit exported from Messina before the earthquake, the exports going chiefly to European countries. There is also a limited shipment of fresh fruit and by-products from Catania and small shipments from Syracuse.

In 1898 the distribution of lemon trees in the provinces of southern Italy, including Reggio di Calabria and Sicily, was as follows:

Reggio di Calabria	1,232,765	Sicily—Continued.	
Sicily:		Caltanissetta	8,210
Messina	1,634,231	Girgenti	56,379
Palermo	2,488,475	Trapani	216,160
Catania	828,640		
Syracuse	460,125	Total	6,924,985

The total number of trees in the provinces of central Italy in 1898 was 798,214, while in the northern provinces there were 564,559 trees, making a total of 8,287,758 lemon trees for the country as a whole. Detailed statistics since 1898 of the different kinds of citrus fruits in Italy are not available, but from the general data at hand it is probable that the number of trees in southern Italy has at least not decreased and has probably increased.

THE COMMERCIAL IMPORTANCE OF THE ITALIAN LEMON INDUSTRY.

From careful inquiries made by Dr. Arthur S. Cheney, the American consul who lost his life in December, 1908, in the earthquake at Messina, it was estimated that the crop of 1907 in Sicily and Calabria amounted to 6,900,000,000 lemons. It is estimated in Italy that one-third or more of the crop is usually converted into by-products, such as citrate of lime, lemon oil, and lemon peel, principally for export. Expressed in terms of boxes of 330 lemons each, the Sicilian and Calabrian crop would equal more than 20,000,000 boxes, or an equivalent of about 64,000 California carloads of 312 boxes each. The quantity that is converted into citrate of lime alone amounts to over 20,000 carloads of fruit, the product of 1907 equaling 23,000 pipes of 672 pounds each. It requires about 100,000 lemons, or the equivalent of nearly a carload of fruit, to make a pipe of citrate of lime. It is estimated by some Italian writers that nearly 2,000,000,000 lemons are required annually for domestic consumption, while the remainder of the crop, or a little over one-third of the total, is exported to different countries in the form of fresh fruit. These figures should be considered only as approximations of the extent of the lemon industry in Italy. The estimate of the domestic consumption is probably too high.

THE EXPORTS OF LEMONS FROM ITALY.

The exports of fresh lemons from Italy have increased more than 75 per cent in the last ten years, or from 325,000,000 pounds in the calendar year 1898 to more than 559,000,000 pounds in 1907. Of the total exports of fresh lemons, the largest proportion is shipped to the United States, it having received from 29 to 41 per cent of the exports annually in the last ten years, the proportion running above 35 per cent in six years out of the ten.

The United Kingdom has received from 17.7 to 25 per cent annually in the last ten years, and Austria-Hungary from 14.4 to 22.8 per cent annually. The remainder of the exports are distributed to Canada, France, Australia, Germany, Russia, and to various other countries in smaller quantities.

The following table, compiled from official statistics,[a] shows the exports of fresh lemons from Italy in quantity and in value during the calendar years 1898 to 1908, inclusive. The proportion exported to the United States has been determined from figures published by the same official source.

TABLE I.—*Exports of lemons from Italy, 1898 to 1908, inclusive.*

Calendar year ended December 31—	Quantity.	Value.	Exports to United States.	Calendar year ended December 31—	Quantity.	Value.	Exports to United States.
	Pounds.		*Per cent.*		*Pounds.*		*Per cent.*
1898	325,504,061	$3,419,486	41.3	1904	514,137,472	$3,600,745	37.3
1899	369,473,041	3,234,489	36.7	1905	452,903,655	3,171,899	32.1
1900	311,563,577	3,000,286	29.0	1906	550,524,096	4,337,525	37.1
1901	368,801,294	3,228,610	29.2	1907	559,549,378	4,408,653	37.8
1902	490,053,960	3,432,077	35.3	1908	540,332,790	[a] 4,257,229	32.7
1903	459,622,020	3,218,948	31.2				

[a] Value for 1908 in Italian trade statistics subject to revision in 1909.

THE IMPORTS OF LEMONS INTO THE UNITED STATES.[b]

The total imports of fresh lemons into the United States during the fiscal years 1898 to 1908, inclusive, practically all of which are received from Italy, are shown in the table following. The figures for 1908 represent the general imports, which are somewhat in excess of the imports for consumption. The reader should bear in mind that the figures from Italian sources cover calendar years, while the American figures cover fiscal years. They are therefore not comparable.

[a] For 1907 and previous years: Movimento Commerciale del Regno d'Italia. For 1908: Statistica del Commercio Speciale di Importazione e di Esportazione del 1 Gennaio al 31 Dicembre, 1908.

[b] United States Imports: Foreign Commerce and Navigation of the United States, Bureau of Statistics, U. S. Department of Commerce and Labor.

TABLE II.—*Total imports of lemons into the United States for consumption, 1898 to 1908, inclusive.*

Fiscal year ended June 30—	Quantity.	Value.	Fiscal year ended June 30—	Quantity.	Value.
	Pounds.			*Pounds.*	
1898	133,347,050	$2,521,985.32	1906 general tariff	138,689,148	$2,934,195.34
1899	208,634,448	4,399,160.72	1906 from Cuba	1,122	26.80
1900	159,384,389	3,655,946.85		138,690,270	2,934,222.14
1901	148,334,112	3,516,877.29			
1902	162,962,091	3,318,908.82	1907 general tariff	153,930,739	4,254,230.56
1903	152,775,867	3,087,244.22	1907 from Cuba	34,519	1,236.00
1904 general tariff	164,042,415	3,507,679.55		153,965,258	4,255,466.56
1904 from Cuba	410	6.00			
	164,042,825	3,507,685.55	1908 general tariff	178,437,835	4,388,247.95
1905 general tariff	139,079,003	2,904,975.44	1908 from Cuba	21,298	393.00
1905 from Cuba	3,528	71.00		178,459,133	4,388,640.95
	139,082,531	2,905,046.44			

The general imports into the United States exceed in variable quantities the imports for consumption from year to year, as the imports for other countries, such as Canada, pass largely through American ports.

About 50 per cent of the total imports are received in the United States from May to July, inclusive, the heaviest shipments in recent years arriving in June. From 70 to 80 per cent of the total imports arrive from March to August, inclusive.

Of the imports of lemons into the United States during the last ten fiscal years, from 82.29 to 89.85 per cent of the total have been received in the customs district of New York; from 3.02 to 8.07 per cent of the total in Boston and Charlestown; from 1.67 to 9.44 per cent of the total in New Orleans; from 0.35 to 1.65 per cent of the total in Philadelphia; from 0.29 to 1.67 per cent of the total in Baltimore; and from 0.26 to 3.34 per cent of the total in other customs districts.

THE DISTRICTS FROM WHICH ITALIAN LEMONS ARE EXPORTED TO THE UNITED STATES.

The lemons exported from Italy to the United States are forwarded principally from Palermo, Messina, and Naples. The fruit shipped from these ports may not have been grown in the vicinity of the ports, as the exporters in one district frequently buy fruit in another and have it shipped in for packing. The exporters in Palermo, for example, may ship lemons from the districts of Messina or Catania which have been forwarded by rail to Palermo to be prepared for export at that point. When shipped, these lemons are recorded as Palermo fruit. The shipments from Naples include most of the lemons from Sorrento, from the Amalfi coast, and from other points in the Sorrentine peninsula.

The following figures, furnished by Mr. Victor L. Zorn, president of the New York Fruit Exchange, show the number of boxes of lemons from these districts received at the port of New York from 1903 to 1908, inclusive:

TABLE III.—*Boxes of lemons received in New York from Italian ports, 1903 to 1908, inclusive.*

Year ended December 31—	Ports of export.			Total.
	Palermo.	Messina.	Naples.	
1903	1,506,850	339,000	57,850	1,903,700
1904	1,581,500	316,900	71,950	1,970,350
1905	1,298,250	98,100	35,600	1,431,950
1906	1,468,800	159,100	75,600	1,703,500
1907	1,647,925	101,400	211,100	1,960,425
1908	1,625,525	85,250	117,350	1,828,125

From these figures it will be seen that from 80.2 to 90.6 per cent of the total exports of lemons to New York since 1903 have been forwarded from Palermo, from 4.6 to 17.8 per cent from Messina, and from 2.5 to 10.8 per cent from Naples. The shipments from Messina in the past have gone largely to Germany, Russia, Austria, Canada, Norway, and Sweden.

THE DISTRIBUTION OF FOREIGN LEMONS IN THE UNITED STATES.

The trade in foreign lemons is confined largely to the eastern half of the United States. In the territory west of the Missouri River, including central and western Texas, the trade is supplied almost exclusively with California lemons. In the Middle West, especially in the territory north of the Ohio River, where the competition between the domestic and foreign lemons is close, probably from 50 to 60 per cent of the lemons handled are imported from Italy. In the South Central States, including eastern Texas, the trade is supplied largely with Italian lemons distributed from New Orleans, and in the territory east of the Alleghenies the trade is supplied principally with foreign fruit distributed from New York, and in smaller quantity from the ports already mentioned.

THE METHODS OF HANDLING FOREIGN LEMONS IN THE UNITED STATES.

METHODS OF SECURING THE LEMONS.

The lemons imported into the United States are usually secured from Italian sources in one of four general business methods, which are believed to be stated in their order of importance as follows:

(1) The purchase of the fruit by the importer in America from the shipper in Sicily at a fixed price, generally including freight.

It is probable that at least half of the lemons imported are purchased by the importer in this manner. Purchases of this kind are generally made on letters of credit issued through an American bank, the letter of credit usually equaling a little less than the purchase price. The shipper and the buyer agree that the fruit shall consist of certain grades and sizes. In making the letter of credit the buyer includes the specifications covering the purchase, as, for example, 60 per cent first grade and 40 per cent second grade, and 50 per cent 300's and 50 per cent 360's, and specifies what proportion of the total payment is to be advanced. The shipper presents this letter of credit with a bill of lading to the correspondent of the bank issuing the letter after the fruit is loaded for shipment, the bill of lading specifying the grades and sizes covered by the letter of credit. The money is then paid by the bank to the shipper.

(2) The shipment of fruit on commission on the strength of an advance by the importer of an amount less than the market value of the fruit at the time of shipment. The advances vary from $1 to $1.75 a box, depending on the condition of the market. The financial transaction is handled through letters of credit, as just described.

(3) The shipment of the fruit for the joint account of the shipper and the importer. Under this method the shipper and the importer agree on a price that represents the cost of the fruit f. o. b. in Italy. The importer advances to the shipper through a letter of credit an amount usually about 25 cents less than the agreed cost price per box. When the fruit is sold, the profit or loss is shared equally by the importer and the shipper.

(4) The shipment on commission without an advance from the consignee in the United States. This method of shipment is limited in extent.

METHODS USED IN SELLING THE LEMONS.

The lemons imported are generally sold at public auction, soon after arrival at the port of entry, by companies who unload the cargo, prepare it for display on the pier or in the auction room, and sell it at public sale under fixed rules and regulations. Some lemons are received each year at the port of New York to be shipped to other points in the United States or to be forwarded in bond to Canada, and small quantities may be received at other ports, to be reshipped in the same manner.

New York is the principal selling point for the foreign lemons used in the eastern half of the United States, with the exception of the Gulf States and the adjoining territory, which are supplied from New Orleans. The fruit for the eastern and interior markets, distributed from New York, is usually purchased by the dealer through resi-

dent New York brokers, but occasionally the dealer attends the sale and purchases the fruit in person.

THE EXPORTS OF LEMON BY-PRODUCTS FROM ITALY.

The principal products made from the lemon are citrate of lime, essential oils, concentrated and raw lemon juice, and green or prepared lemon peel. The by-product business is confined largely to Sicily and Calabria. This business holds the same relation to the lemon industry of Italy that the evaporating industry holds to the apple industry of western New York and of other parts of the United States or that the canning and drying industries hold to the deciduous fruit business of California. It makes it possible either to convert the low grades of fruit into useful products or to use a variable proportion of the better grades of fresh fruit in this manner during the months when prices are low or when the foreign demand for fresh fruit temporarily decreases.

THE EXPORTS OF CITRATE OF LIME.

Citrate of lime, or calcium citrate, is the most important by-product of the lemon and is an intermediate product in the manufacture of citric acid. Citric acid is not made in Italy. The citrate of lime is exported to different countries and is there converted into the acid. The exports of citrate of lime from Italy have increased from about 3,000,000 pounds in 1899 to nearly 17,000,000 pounds in the calendar year 1908. The United States is the heaviest buyer of this product, having received from 32.5 to 40.7 per cent of the total exports from Italy in the last ten years except in 1904, when the proportion dropped to 26.8 per cent. France and the United Kingdom are the next heaviest importers, the quantities received sometimes nearly equaling the exports to the United States.

The table following, from Italian statistics, shows the total exports of citrate of lime from Italy during the calendar years 1899 to 1908, inclusive, with the percentage of the total exported to the United States:

TABLE IV.—*Exports of citrate of lime from Italy, 1899 to 1908, inclusive.*[a]

Calendar year ended December 31—	Quantity.	Value.	Exports to United States.	Calendar year ended December 31—	Quantity.	Value.	Exports to United States.
	Pounds.		*Per cent.*		*Pounds.*		*Per cent.*
1899	3,142,248	$151,296	32.8	1904	12,193,764	$1,067,483	26.8
1900	3,743,448	196,628	37.6	1905	9,096,050	875,929	37.9
1901	3,120,202	147,502	35.3	1906	11,353,362	1,292,085	40.7
1902	7,517,541	329,055	32.5	1907	13,598,990	2,142,902	34.6
1903	7,229,617	632,905	38.0	1908	16,997,856	[b] 2,678,489	31.3

[a] For 1907 and previous years: Movimento Commerciale del Regno d'Italia. For 1908: Statistica del Commercio Speciale di Importazione e di Esportazione del 1 Gennaio al 31 Dicembre, 1908.

[b] Value for 1908 in Italian trade statistics subject to revision in 1909.

THE IMPORTS OF CITRATE OF LIME INTO THE UNITED STATES.

The total imports of citrate of lime into the United States for the fiscal years 1894 to 1908, inclusive, are given in the table following:

TABLE V.—*Imports of citrate of lime into the United States for consumption, 1894 to 1908, inclusive.*[a]

Fiscal year ended June 30—	Quantity.	Value.	Fiscal year ended June 30—	Quantity.	Value.
	Pounds.			*Pounds.*	
1894	443,981	$52,137	1902	3,066,904	$293,293
1895	608,214	59,458	1903	2,657,110	240,466
1896	668,106	66,388	1904	2,926,529	274,130
1897	496,291	42,090	1905	3,444,344	355,728
1898	1,026,467	84,789	1906	3,903,234	534,977
1899	1,577,804	157,432	1907	3,872,924	726,626
1900	1,944,863	204,243	1908	3,853,105	580,293
1901	2,416,088	299,583			

[a] United States Imports: Foreign Commerce and Navigation of the United States, Bureau of Statistics, U. S. Department of Commerce and Labor.

THE EXPORTS OF ESSENTIAL OILS FROM CITRUS FRUITS.

The exports of essential oils of all citrus fruits, including lemon, orange, and bergamot, are usually lumped in Italian statistics. From 1900 to 1905, during which time the statistics were separated, the lemon oil comprised from 62.5 to 84 per cent of the total exports of citrus-fruit oils. The total exports have approximated 1,000,000 pounds a year during the last ten years. From 24.9 to 38.8 per cent of the total exports of essential oils have been sent to the United States during that period.

The following table, from Italian statistical sources, shows the total exports of essential oils of lemon, orange, and other citrus fruits from Italy for the calendar years 1898 to 1908, inclusive, with the percentage of the total exported to the United States:

TABLE VI.—*Exports of essential oils of lemon, orange, and other citrus fruits from Italy, 1898 to 1908, inclusive.*[a]

Calendar year ended December 31—	Quantity.	Value.	Exports to United States.	Calendar year ended December 31—	Quantity.	Value.	Exports to United States.
	Pounds.		*Per cent.*		*Pounds.*		*Per cent.*
1898	1,010,491	$1,150,003	24.9	1904	1,419,695	$2,485,697	38.3
1899	1,298,130	1,590,997	26.6	1905	1,292,136	2,262,358	31.1
1900	1,100,812	1,541,900	27.8	1906[b]	971,334	935,373	36.7
1901	1,101,504	1,398,226	28.1	1907[b]	1,034,816	1,358,870	41.5
1902	1,425,438	1,871,814	38.8	1908[b]	1,051,256	[c] 1,380,458	33.2
1903	1,233,210	1,619,391	34.8				

[a] For 1907 and previous years: Movimento Commerciale del Regno d'Italia. For 1908: Statistica del Commercio Speciale di Importazione e di Esportazione del 1 Gennaio al 31 Dicembre, 1908.

[b] Since 1905 all the exports stated are lemon oil.

[c] Value for 1908 in Italian trade statistics subject to revision in 1909.

The quantity of lemon oil included in the exports shown above, from 1900 to 1908, inclusive, is given in the table following:

TABLE VII.—*Exports of lemon oil from Italy, 1900 to 1908, inclusive.*[a]

Calendar year ended December 31—	Quantity.	Calendar year ended December 31—	Quantity.
	Pounds.		*Pounds.*
1900	743,024	1905	840,417
1901	826,446	1906	971,334
1902	1,197,213	1907	1,034,816
1903	970,565	1908[b]	1,051,256
1904	886,990		

[a] For 1907 and previous years: Movimento Commerciale del Regno d'Italia. For 1908: Statistica del Commercio Speciale di Importazione e di Esportazione del 1 Gennaio al 31 Dicembre, 1908.
[b] Value for 1908 in Italian trade statistics subject to revision in 1909.

THE IMPORTS OF LEMON OIL INTO THE UNITED STATES.

The following table shows the total imports of lemon oil into the United States for the fiscal years 1898 to 1908, inclusive:

TABLE VIII.—*Total imports of lemon oil into the United States for consumption, 1898 to 1908, inclusive.*[a]

Fiscal year ended June 30—	Quantity.	Value.	Fiscal year ended June 30—	Quantity.	Value.
	Pounds.			*Pounds.*	
1898	160,264	$117,021.00	1904	294,568	$174,649.00
1899	237,302	185,728.00	1905	310,056	175,852.00
1900	261,978	211,800.00	1906	370,270	218,749.00
1901	268,341	231,040.78	1907	487,717	423,133.00
1902	391,485	282,092.00	1908	440,326	592,533.00
1903	361,210	233,487.00,			

[a] United States Imports: Foreign Commerce and Navigation of the United States, Bureau of Statistics, U. S. Department of Commerce and Labor.

THE EXPORTS OF CONCENTRATED LEMON AND CITRON JUICE.

The exports of concentrated lemon and citron juice, which are lumped together in Italian statistics, have decreased from about 5,000,000 pounds in 1899 to about 1,400,000 pounds in 1907. The United Kingdom and France are the largest receivers. The proportion of the total exported to the United States has varied from 1.1 to 10.6 per cent in ten years. In the last five years the proportion has varied from 5.6 to 10 per cent.

The following table shows the total exports of concentrated lemon and citron juice from Italy for the calendar years 1898 to 1908, inclusive:

TABLE IX.—*Exports of concentrated lemon and citron juice from Italy, 1898 to 1908, inclusive.*[a]

Calendar year ended December 31—	Quantity.	Value.	Exports to United States.	Calendar year ended December 31—	Quantity.	Value.	Exports to United States.
	Pounds.		*Per cent.*		*Pounds.*		*Per cent.*
1898	5,205,333	$273,415	8.0	1904	4,728,694	$269,078	10.0
1899	5,496,784	288,724	1.5	1905	2,462,019	150,339	6.0
1900	4,407,921	231,531	5.3	1906	2,074,109	118,023	6.9
1901	4,117,132	233,465	2.9	1907	1,443,146	94,753	7.5
1902	4,989,941	270,838	1.1	1908	1,844,387	[b] 121,098	10.6
1903	3,180,829	175,430	5.6				

[a] For 1907 and previous years: Movimento Commerciale del Regno d'Italia. For 1908: Statistica del Commercio Speciale di Importazione e di Esportazione del 1 Gennaio al 31 Dicembre, 1908.
[b] Value for 1908 in Italian trade statistics subject to revision in 1909.

THE EXPORTS OF RAW CITRON AND LEMON JUICE.

The exports from Italy of raw citron and lemon juice combined have varied from 1,357,827 to 4,474,044 pounds in the last ten years. The proportion exported to the United States has varied from 4.1 per cent of the total, the lowest, in 1900, to 16.1 per cent, the highest, in both 1899 and 1902.

The table following, from Italian statistical sources, shows the total exports of raw citron and lemon juice from Italy during the calendar years 1898 to 1908, inclusive, and the percentage of the total shipped to the United States:

TABLE X.—*Exports of raw citron and lemon juice from Italy, 1898 to 1908, inclusive.*[a]

Calendar year ended December 31—	Quantity.	Value.	Exports to United States.	Calendar year ended December 31—	Quantity.	Value.	Exports to United States.
	Pounds.		*Per cent.*		*Pounds.*		*Per cent.*
1898	1,725,337	$18,125	11.3	1904	2,322,790	$23,385	5.7
1899	1,842,844	19,359	11.6	1905	1,883,409	18,961	9.9
1900	2,307,137	24,237	4.1	1906	4,474,044	34,974	8.4
1901	1,357,827	14,264	6.3	1907	1,872,606	21,311	10.9
1902	2,250,919	23,646	16.1	1908	2,039,275	[b] 23,208	.....
1903	2,035,307	20,490	13.8				

[a] For 1907 and previous years: Movimento Commerciale del Regno d'Italia. For 1908: Statistica del Commercio Speciale di Importazione e di Esportazione del 1 Gennaio al 31 Dicembre, 1908.
[b] Value for 1908 in Italian trade statistics subject to revision in 1909.

THE EXPORTS OF LEMON, ORANGE, AND OTHER CITRUS-FRUIT PEEL.

The exports of lemon, orange, and other citrus-fruit peel, green or dried, which are combined in Italian statistics, have increased from 1,598,351 pounds in 1898 to 7,342,273 pounds in 1908. The propor-

tion of the total exports shipped to the United States in the last ten years has varied from 0.2 per cent, the lowest, in 1900, to 6.2 per cent, the highest, in 1904. The heaviest importer is the United Kingdom.

The following table shows the total exports from Italy of lemon, orange, and other citrus-fruit peel, green or dry, during the calendar years 1898 to 1908, inclusive, and the proportion of the total exported to the United States:

TABLE XI.—*Exports of lemon, orange, and other citrus-fruit peel, green or dry, from Italy, 1898 to 1908, inclusive.*[a]

Calendar year ended December 31—	Quantity.	Value.	Exports to United States.	Calendar year ended December 31—	Quantity.	Value.	Exports to United States.
	Pounds.		*Per cent.*		*Pounds.*		*Per cent.*
1898	1,598,351	$34,981	0.6	1904	4,615,376	$101,011	6.2
1899	6,184,406	135,351	0.6	1905	3,737,496	81,798	1.9
1900	3,862,312	83,217	0.2	1906	5,859,885	128,248	1.8
1901	4,498,531	98,454	2.3	1907	5,475,179	119,829	1.6
1902	3,172,451	69,432	2.6	1908	7,342,273	[b] 160,692	.....
1903	2,798,106	61,239	1.8				

[a] For 1907 and previous years: Movimento Commerciale del Regno d'Italia. For 1908: Statistica del Commercio Speciale di Importazione e di Esportazione del 1 Gennaio al 31 Dicembre, 1908.

[b] Value for 1908 in Italian trade statistics subject to revision in 1909.

A glance at the figures shown in the foregoing tables brings out clearly that the two most important items of the Italian lemon industry, namely, the export of fresh fruits and citrate of lime, have increased steadily in the last ten years. The essential-oil business has remained nearly stationary, the exports of concentrated lemon and citron juice have decreased, the exports of raw juice have not varied widely, while the exports of citrus-fruit peel have shown wide variation and on the whole have increased.

The relation of the United States to the Italian lemon industry is brought out in the figures. Over one-third of the fresh fruit has recently been shipped to the United States, about one-third of the citrate of lime, and one-third, more or less, of the essential oils.

THE RATES OF DUTY ON LEMONS AND THEIR BY-PRODUCTS ENTERING THE UNITED STATES.

Under the tariff act of 1897 the rate of duty on lemons entering the United States is 1 cent per pound. Under the reciprocity treaty with Cuba, December, 1903, the tariff was made 1 cent per pound, less 20 per cent on fruit from that country. The tariff on citric acid is 7 cents per pound, the imports of which in 1908 were 171,795.6 pounds, valued at $62,804. Citrate of lime and lemon oil are entered free of duty. There is no duty on lemon and orange peel not prepared, but there is a duty of 2 cents per pound on similar material preserved, candied, or dried, the imports of which in 1908 were 613,834.5 pounds, valued at $40,342.

THE SEASON OF LEMON RIPENING IN ITALY.

There is a wide variation in the season of ripening of the lemons of Italy and an equally wide variation in the character of the fruit from different sections, as well as in the fruit that is harvested at different periods of the year in the same section.

The lemon season is considered to begin on October 1 in Italy and ends on September 31 following. The earliest fruit ripens in the Syracuse district, where the first picking is made from October 1 to 15. The harvesting in the Catania and in the Messina districts begins about ten days later than in Syracuse. The Palermo harvest commences from December 1 to January 1, and occasionally by November 1. The soil is heavier in this district and the fruit can be held on the trees longer than in other districts. The fruit on the Sorrentine peninsula, including the Amalfi coast, is the latest to ripen, the harvest beginning about February 1. There is also a summer crop of lemons in the Messina and Catania districts, called the "Verdelli" lemon. The methods of producing this crop will be described later.

The harvesting season in each district covers a period of seven to ten months, more or less, depending on its character. The heaviest yields of each locality usually occur during the second, third, and fourth months in the season, though in some regions, like Palermo, where the altitude and soils are variable, the fruit may be harvested practically throughout the year. The fruit gathered in the first harvest in each section is somewhat inferior in keeping quality, usually on account of its immaturity and irregularity in condition. The fruit harvested in December and January is supposed to have the best keeping quality, and considerable fruit was stored before the earthquake in the Messina district in cellars for shipment in March or April to European markets, especially to Russia, Austria, Norway, and Sweden. Practically no stored fruit is shipped to the United States, though small quantities are sometimes sent to Canada. The fruit harvested in October and during the period from May to September, inclusive, is practically all used for export. That harvested from November to April, inclusive, is used principally in the manufacture of by-products, with some of it entering the export trade as fresh fruit. In the Palermo district the heaviest exports to all countries occur from March to July, in the Messina and Catania districts from November to February, and on the Sorrentine peninsula from June to September.

THE CHARACTER OF THE LEMONS IN DIFFERENT REGIONS OF ITALY.

There is a wide variation in the character of the fruit grown on different soils and in different regions. The lemons produced on the lighter soils are rougher in texture and poorer in quality than the lemons from the heavier lands. They ripen earlier and are said to have poorer keeping qualities. The soil along the eastern coast is generally gravelly and light in texture, except in the upper valleys between Messina and Giarri. Only a small proportion of the fruit harvested near this coast, that cut in October, and the Verdellis are exported; the rest of it is converted into by-products. On the other hand, from 80 to 90 per cent of the firm, finer textured fruit in the upland valleys on the same coast is generally used for export. There is often a difference of 50 to 75 cents a thousand in the price paid for the upland or heavier land lemons in comparison with the fruit grown on the lighter soils near the coast. The fruit grown on the north coast of Sicily enters largely into the export trade. Probably as much as 90 per cent of the lemons of the Palermo district is exported, two-thirds of the exported fruit going to America. Of the total exports from the Messina district less than one-half is usually sent to America, the rest of the fruit going to European markets, especially Germany, Russia, Austria, Norway, and Sweden, with lesser quantities to Australia and Canada. The fruit in the Palermo district is smaller and better in texture than the lemons from Messina. While the crop at Messina averages two-thirds of the 300 lemon per box size, not over one-third is usually of that size in the Palermo district, the 360 size predominating in the latter section.

THE CHARACTER OF THE LEMONS EXPORTED TO DIFFERENT MARKETS.

Of the lemons exported to the United States, a large proportion are of the highest grades, that is, the finest in texture and free from blemishes. Of the fine-textured lemons the sizes packing 300 and 360 to the box are shipped largely to the United States, the 300 size predominating in the shipments to the northern markets and the 360 size in the exports to the southern districts. The largest lemons, the 200 size, predominate in the shipments to England. The English markets receive large quantities of the coarser grades of fruit. The German markets take a large lemon, but smaller than England. France takes a lemon medium to small in size, similar to the United States, and uses a good deal of coarse fruit, while a 330 size is frequently sent to Russian markets, this size including a mixture of

300 and 360 lemons. The size of fruit shipped to a country depends somewhat on the form of the duty existing in that country. Where the duty is based on weight, the medium to small sizes are generally exported; where it is based on the number of lemons the large sizes are exported.

TERMS APPLIED TO LEMONS RIPENING AT DIFFERENT PERIODS.

There are several terms applied to the lemons that ripen at different periods in Italy, though the terms are not always applied consistently to the same kind of fruit. The lemon trees bloom normally in April and May in southern Italy. There may be more or less blossoming through the year, and the terms are usually applied to the fruit that results from the blossoms that appear in different seasons.

The term "Limoni" is applied to the main crop of fruit maturing from the normal flowers of the preceding season.

The term "Maggiolini," or locally "Bianchetti," is applied to the fruit that ripens in April and May and which is produced from irregular bloom following immediately after the normal blooming season. The Maggiolini lemons are somewhat light in color. They are high-grade fruits and are largely exported.

The term "Bastardi" is applied to large irregular lemons, usually flattened at the ends. The texture of the skin is medium in quality, and it adheres firmly to the flesh. The fruit is acid, generally seedless, and is produced from blossoms that appear irregularly late in the season. The Bastardi lemons usually ripen in August.

The term "Basterdoni" is often applied to the largest Bastardi lemons. They ripen in September.

The term "Verdelli" is applied to a crop of lemons that ripens in the summer. The crop is produced artificially by withholding the water from the trees during June and July. About the first of August the trees are stimulated by a quick-acting fertilizer and an abundance of water. Two weeks later the trees begin to bloom and the fruit is harvested during the following summer.

THE VERDELLI LEMONS.

The Verdelli lemons are of enough importance to warrant a special description. In producing the crop of these lemons the object is to have the fruit mature in June or July, during the season of highest prices. They are usually grown not oftener than every other year in the same grove, as an annual production is said to be detrimental to the vitality of the tree, but on some of the lighter soils the Verdellis are produced annually. The Verdelli crop is produced principally in the region between Messina and Giardini, on the east coast of Sicily, though the system is practiced to a limited extent in the districts on

the northern coast. The crop of Sicily matures with the later part of the normal crop of the Sorrentine peninsula.

METHOD OF PRODUCTION.

On the heavier soils the earth is removed from the base of the tree about June 1 until the larger roots are exposed to a depth of a foot in a diameter of 6 to 10 feet. On the sandy soils the earth may not be removed from the roots. No water is applied to the trees for sixty days. At the end of the drying-down period the foliage is wilted, but is not supposed to have begun to shed. The aim then is to stimulate the tree to the greatest possible extent. This is accomplished by adding a quick-acting fertilizer, like composted manure, or a chemical fertilizer, usually of sulphate of ammonia, at the rate of 2 to 2½ pounds per tree. Occasionally nitrate of soda is used. The manure or fertilizer is mixed with the soil that was removed from the basin, or it is dug into the sandy soils where the basins are not made. The basins are then filled with the soil and the fertilizer, and water is applied around each tree once a week, or oftener if the soil absorbs it, for a period of two or three weeks. If the tree responds, the blossoms begin to appear with the new growth in two weeks, and the old foliage gradually drops off.

It is easier to produce the Verdellis on the lighter soils and on young trees. Sometimes the trees, especially in the older groves, do not respond to the treatment. If the weather is cool and there is an abundance of dew following the blooming season, the young lemons may be killed by the wet, wilted blossoms which adhere to them for some time. Under these conditions the old blossoms are often removed by beating the branches with poles. It is quite common to produce a Verdelli crop on a grove which failed to set a satisfactory crop in the spring.

THE LEMON GROVES OR GARDENS OF ITALY.

The lemon gardens of Italy are variable in size. The majority contain not more than a few trees or a few acres each at most. There are some groves of several hundred acres each in the territory between Messina and Catania and in the Palermo district, a few of the largest plantings amounting to 1,500 to 2,000 acres. The larger groves are usually under the direct management of the owners, while the smaller ones may be worked by the owners or by tenants who lease them from the owners or from one who already holds a lease.

The trees in the gardens on the Sorrentine peninsula, and to a lesser extent in other sections, are frequently planted irregularly, without reference to their position in rows or to the distance apart. This is especially true of many of the gardens in the rough lava beds on the slopes of Etna, in the Catania district, where the lemon trees

are often planted in small walled-up pockets containing a dozen or more trees. In other sections where the areas of adaptable land are larger the trees are planted with regularity. There is a wide variation in the distance apart of planting the trees. In Sicily and in Calabria they vary from 12 to 18 feet apart each way; on the Sorrentine peninsula and in the vicinity of Naples, from 8 to 12 feet, and in the districts farther north the trees are planted even closer together. The yield of fruit also varies widely. In the well-cared-for irrigated groves of Sicily the trees bear from 800 to 1,200 lemons each, and sometimes an unusually well-handled grove produces from 1,200 to 2,000 lemons per tree. On the Sorrentine peninsula, where there is a short water supply and where the trees are planted closer together and are smaller, the average is not over 400 lemons per tree, while the yields are still smaller in the gardens farther north.

HANDLING THE LEMON GARDEN.

PROPAGATION.

There are no extensive nurseries in Italy where lemon trees are grown as they are in the United States. The stocks of bitter orange (*Citrus bigaradia*) are usually grown by the owners in small seed beds under the bearing lemon trees. The bitter orange grows wild in Sicily and in the mountains of Calabria, and is now used universally as a stock on account of its resistance to the gum disease, which devastated the groves of Sicily about thirty years ago, when the trees were propagated on lemon stocks.

The orange seeds are sown in the spring in a well-prepared bed, and the seedlings are usually transplanted when a year old at a distance apart of 10 inches or a foot in small clumps under the bearing trees or in distinct areas. When the trees reach a diameter of 1 to 2 inches and a height of 5 to 6 feet they are transplanted to the garden or grove. They may or may not have been budded or grafted with the desired type of lemon before transplanting. The lemon bud is usually inserted from 2 to 3 feet from the ground and the top of the lemon tree is started from 4 to 6 feet from the ground. As the trees grow older the lower shaded branches die and, like the apple trees of the eastern United States, the main branches lose the lower bearing wood and the tree becomes increasingly high headed and spreading. In many of the old groves in Sicily the lowest fruit-bearing branches are from 6 to 10 feet from the ground. A high-headed grove is shown in Plate II, figure 1, while a low-headed lemon grove in California is shown in Plate II, figure 2, for comparison. Many of the closely planted lemon trees are irregular in form in both trunk and top, the trunks of many of the trees assuming a crooked, almost tortuous, outline.

While the lemon trees are young it is a common practice to grow cereals or vegetables between the rows. This crop may be grown by the owner or by the tenant, or the land may be sublet to a second or third party for this purpose.

PRUNING.

The lemon trees of Italy are not pruned systematically as they are in California. Pruning in Sicily means the cutting out of dead wood and the shortening of the vigorous suckers every year or two, and the opening of the top when the tree becomes dense. The object of pruning is similar to the general practice of pruning orange trees in California, though much more roughly done; an ax is often used in cutting out the wood. No system of pruning has been developed the purpose of which is to hold the tree low headed, to modify the density of the tree, to stimulate the production of new bearing wood, or to modify the growth of the bearing wood in different parts of the tree. The growers generally believe that the low, dense-headed tree produces a tender, poor-keeping lemon and that the scale insects and diseases are much less serious in the trees with the high, open, spreading form which admits the air and sunlight to the greatest extent.

TILLAGE.

The tillage of the Italian lemon groves is practically all done by hand labor; occasionally it may be done in the larger groves with oxen and a primitive one-handled plow, though plowing in the lemon groves in Italy is a rare operation. The land is generally turned over from 5 to 10 inches deep with a short, heavy hoe twice a year, in February or March and again in September, and twice lightly, 3 inches or more deep, in May or June and in November, to turn under the weeds. The relation of tillage to the conservation of moisture and to the liberation of plant food is not understood.

FERTILIZING.

The principal fertilizer used in the lemon groves is composted sheep, goat, or cow manure. Chemical fertilizers have come into use to a limited extent in recent years. Sulphate of ammonia is the principal source of nitrogen, with nitrate of soda used to a less extent; sulphate of potash and ashes are used chiefly for potash; and bone meal, slag, and ground rock are among the sources of phosphoric acid. The commercial fertilizers have been experimented with in recent years in connection with cover crops and with manure. Several factories have been organized in Sicily for the manufacture of commercial fertilizers.

There is no definite system of fertilizing used by the Italian lemon growers. There seems to be the same lack of exact knowledge

among the growers as to the fertilizer requirements of the trees as there is among the lemon growers of the United States. There is no agreement as to the kind of fertilizers or the quantity to use, or the time or method of application. The fertilizer that is advocated most plausibly is likely to be used most generally, and different growers using different kinds of fertilizers are likely to get equally good results if the land is kept in good physical condition. All are agreed that the trees need to be fed liberally, though they are not fertilized as regularly or to the extent practiced by the growers of California.

There is a general agreement among the growers that the physical qualities of the soil must be maintained by the frequent use of manure or by turning under a cover crop of weeds. As in California, some of the growers have an impression that stable manure makes the fruit coarse in texture and of poorer keeping quality. The manure is applied generally in the spring, but sometimes in the fall. It is dug into the irrigating basin around the tree or in the bottom of the irrigating furrows. In some groves the manure is applied in the basin around the tree every other year, and, in the years between, farther away from the tree in the bottom of deep furrows, in order to reach the fine, distant feeding roots. It is not practicable to discuss the fertilizing question further, as there is an endless variation in the methods of application and in the quantities of manure and commercial fertilizer in use. The variation in the quantity of manure per tree will run from 40 to 150 pounds, and in chemical fertilizer from 2 to 10 pounds, depending on the nature of the fertilizer, the condition of the trees, and the general practice of the grower.

IRRIGATION.

Irrigation is practiced more or less in most of the lemon-producing sections of Italy. There is said to be an abundance of water in many parts of Sicily, but no comprehensive system of water development or of commercial water management, such as the California citrus-fruit growers have developed, has been attempted in Italy. Water is therefore likely to be scarce in dry seasons. In the fall of 1908, following a prolonged drought, the groves on the Sorrentine peninsula and in many parts of Sicily were suffering from lack of water. The landowner may lead the water from the mountains in terra-cotta pipes to reservoirs or wells on his place, or the water may be distributed directly from the mountain supplies to the groves. The excess water not needed by the large landowner is sometimes distributed in canals to tenants or independent landowners who purchase the land and a right to the water from him. In other sections the water may be pumped by the grower from dug wells located on the place. The water is sometimes raised in bucket pumps driven

by steam power, but more often by oxen operating a windlass. It may be distributed directly from the pump to the land or pumped first to a reservoir and distributed later by gravity flow.

The water is distributed in the groves in a variety of ways. Usually there are brick or terra-cotta tile ditches in which the water is carried to the heads of the rows. A few cement ditches, similar to those used in the groves in southern California, have been constructed in recent years. If the land is sloping, a main furrow is run between the rows at right angles to the ditches mentioned. The water is run from the ditch into this furrow and is led out to a square basin constructed around each tree or around two trees, or to short side furrows in place of the basins under the trees. The basins are shown plainly in Plate II, figure 1. The method of distributing the water in the grove depends on the nature of the land, its contour, and on the supply of water. The basin system of irrigation is used when the water supply is comparatively abundant. The furrow method is more economical of water. The distributing furrows are made by hand or occasionally with a plow after the spring cultivation, and the basins are formed by banking up the earth, as shown in the illustration (Pl. II, fig. 1). In some sections where the winter rainfall is excessive the basins and ditches are reshaped in the fall to carry off the excess of water not absorbed by the ground.

The irrigating season begins in Italy in April or May and ends in September or October, depending on the ending and the beginning of the rainy seasons. The rainfall in Sicily is more abundant than in southern California, the annual rainfall in the Messina district for ten years past, according to data gathered by the late Doctor Cheney, amounting to 30 to 40 inches.

Cultivation, however, is not practiced in Italy to conserve moisture. The land is not hoed after each irrigation, and the loss of water from evaporation is large. The bearing trees are flooded every week or two on the sandy soils, and every two or three weeks on the heavier land. On the heavier soils around Palermo some of the growers irrigate the trees only when the foliage begins to wilt. Under such conditions the trees may not be irrigated oftener than three times during the season.

PROTECTION AGAINST FROST.

Occasionally the Italian lemon crop is badly injured by frost, especially when the trees are in bloom in April or May. The temperature on the mainland on the Sorrentine peninsula generally drops below freezing every winter, and it often freezes in Sicily. In the former section an elaborate system of trellises is built over many of the groves, and mats of straw or of fine chestnut twigs are used to cover the trellises from November to April or May, when the mats

are removed. Occasionally they are rolled up and are left on the trellises during the summer. On the Amalfi coast, where the lemons are grown on terraces one above the other, the trees on each terrace are covered with a trellis from 8 to 10 feet in height, as shown in figure 2. The new wood is not allowed to grow above the trellis, but the fine wood and smaller suckers are tied to it once a year. The strong-growing suckers and the excess of wood are pruned off. The tree assumes a flat, umbrella shape, as shown in figure 3, and the lemons hang down and are largely picked from beneath the trellis. This form of tree training produces a partial shade, and the lemons grow-

FIG. 2.—A trellis over a lemon grove. Walnut trees are growing through the trellis. Straw mats are fastened to the trellis for protection from frost from November until April or May.

ing in it are comparatively fine and smooth in texture. As the trees bloom late in the spring, the fruit matures largely in the summer months. The fruits known in the market as the "Sorrento" or the "Majori" lemons are grown under this system. No systematic attempt is made to protect the groves against frost by the use of fires or smudges.

HANDLING THE LEMON CROP.

SELLING THE FRUIT.

There are several methods of selling the lemon crop in Italy. Practically none of the fruit is exported by the grower except occasionally

in the case of large, experienced producers. There are no cooperative handling or marketing agencies similar to the marketing organizations that have been formed by the California lemon producers. The grower sells his fruit usually through a broker to the exporter or to the manufacturer of by-products. The broker acts as an agent for both parties in the final settlement of the transaction, often shipping the fruit for the grower, receiving the money, and depositing it or using it in purchases for the grower, as there are few business transactions between the producer and the Italian business man, on account of the bargaining that must be done before a sale of fruit is made.

FIG. 3.—Lemon trees growing under a trellis, showing the flat, umbrella form of the trees caused by tying down their branches.

The lemon crop may be sold by the grove as a whole for the season, the purchaser taking all the fruit, or each picking may be sold separately by the thousand lemons, a thousand, as understood in the Italian industry, meaning 1,040 lemons, weighing 120 kilos, or about 260 pounds. In the by-product districts of Syracuse, Messina, and Catania the crop is generally sold as a whole for the season or, to a lesser extent, at an agreed price per thousand lemons for the crop of the season. In the upper valley or highland regions of the same districts, where the lemons are finer in grade and better for export, the fruit is usually sold by the thousand lemons at each picking. In the Palermo district the fruit is generally sold by the thousand at each

picking or, to a less extent, by the thousand for the season, or as a whole crop on the trees. The buyer usually picks the fruit when it is sold by the season. The grower usually picks it when sold at each picking. In the Messina district considerable fruit is brought to the city by the growers to be sold there either through a broker or directly to an exporter or manufacturer. The price paid the grower for the fruit has varied from $1.50 to $3.50 per thousand in the last few years.

The handling of the lemon crop of Italy previous to the season of 1908 was based on a system of money advances extending from the exporter of the by-product or the fresh-fruit handler down through the various parties through whose hands the fruit or by-product passed until it reached the producer. The advances were made before the fruit was harvested, usually at the time of closing a contract between the parties having to do with the product in question, to defray the operating expenses of the different parties. The system had grown to such an extent that each party in a series of transactions became a banker for the next lower party depending on him financially. An attempt was made to abandon the system before the season of 1908 by the exporters of by-products, with the result that the lemon trade was in an uncertain and demoralized condition when these observations were made in September. Contracts for by-products and for fresh fruit had not been made with the producers at that time on account of the uncertain market conditions in foreign countries, and at least a year's supply of citrate of lime that had been bought at high prices was on hand in the Messina district. Many of the producers who previously had made contracts earlier in the season and had received an advance on the contract were in need of financial assistance at that time. The citrate of lime in the Messina district is said to have been destroyed by the earthquake.

METHODS USED IN THE GARDENS.

On account of the broad-spreading, high-headed trees it is necessary to use ladders in picking the lemons. The fruit is placed in padded baskets. From the picking baskets the fruit may be placed in larger padded baskets, in which it may be carried out of the grove to the packing house. On the Amalfi coast it is common to see women carrying the baskets of lemons from the groves to the packing houses, often a distance of several miles.

If to be used for by-products, the lemons are pulled from the trees. If the fruit is to be used for export or for export and by-products, the picker, generally a man, breaks off the stem with the thumb and finger, leaving a stem attached to the fruit an inch or more in length. For export a man can pick about 5,000 lemons a day; for by-products, from 8,000 to 12,000. The fruit is picked by size, as in California.

If the fruit is to be used in a by-product factory, it is drawn there in bags or in baskets loaded into donkey or ox carts.

The fruit that is used both for export and for by-products may be taken to a packing house on the place, where the stems are cut close with shears by either men or women. It is then roughly graded by women into export and by-product fruit, the rough lemons and low grades going for the latter purpose. Sometimes, as shown in the picking scene in Plate III, figure 1, the stem clipping and grading is done in the grove. In this case the lemons are piled on straw, the stems are cut short, and the fruit is roughly graded, after which the export fruit is delivered to the packing house on the place or, if near by, to the packing house of the exporter. On the Amalfi coast the lemons are often drawn in hand carts from the groves to the packing houses. The women carry the lemons out of the high groves in covered baskets to the carts and then draw them to the packing houses. When the fruit is packed on the place it is allowed to wilt for two or three days or longer, after which the lemons are wrapped, generally by the women who grade them. The packing is done by men. The boxes are then delivered to the packing house of the exporter, where the fruit is always regraded before shipping.

METHODS USED IN THE PACKING HOUSES.

The handling of the fruit after it reaches the packing house is simpler in some ways than the American method of lemon handling. The sweating or coloring of the lemons is not practiced, and none of the fruit is washed. The lemons are comparatively clean as they come from the tree. The fruit hangs too far from the ground to be affected with brown-rot, if the disease exists in Italy, and the lemons are not covered with the dust arising from cultivation and from a loose soil, as the California fruit is likely to be. If the lemons are dirty, they are sent to the by-product factory. The fact that the exported lemons are not washed probably adds to the keeping quality of the fruit after it reaches the market.

Comparatively few of the Italian lemons are stored. The bulk of the fruit is shipped soon after picking, only the best grades entering the export trade to the United States. There may be from three to five grades selected for export to different countries. The tree-ripe lemons are shipped to other countries or are used in making by-products. The quick shipment of the fruit that corresponds only to the silver-green or the light-yellow lemons of California probably adds to the keeping quality of the Italian lemons. The dark-green, as well as the tree-ripe fruit, is not considered of good enough keeping quality to be shipped to the United States.

The methods of grading and packing Italian lemons are more complicated than the American methods. If the fruit has not already

been wilted in the garden, the lemons are generally allowed to stand a few days on arrival in the house, either in the packages or in piles on the floor. There are many differences in the details in handling the fruit in the packing houses. The packing-house operations are not systematized to the extent practiced in American houses. In a house in Palermo the lemons were in a pile on the floor 3 feet deep or more, probably containing a thousand boxes. The fruit had been roughly graded by the grower, but it was regraded by the exporter. The grading was done by women. Other women wrapped the fruit, twisting the wrapper at both ends of the lemon except the fruit for the top tiers of the box, which is wrapped after the American method. The wrapped lemons were then placed in baskets. The fruit was of the 300 and 360 sizes. The lemons of one size were then placed in the boxes by boys as rapidly as the men who do the packing could place them in position in the box. In the United States the packer sizes, wraps, and packs the fruit. In Italy the packer's work is concerned only with arranging the fruit in the box. A good workman will pack 70 boxes a day.

The interior of a packing house in Catania is shown in Plate III, figure 2. The padded bins are used in grading, sizing, wrapping, and packing the fruit. The method of packing differs from that followed in America principally in the double twist on the wrapper and in the use of bright-colored pictures on the wrappers and often on the paper that is used in lining the boxes; also in the use of shredded paper, gold and silver colored tinsel, etc., for embellishing the package. There have been several sizes of boxes in use in the export trade, but an effort is being made to use for the United States boxes similar in size to the California box.

In the Messina district considerable of the fruit of the November and December crop is stored in cellars for export to European markets in the spring. The fruit is wrapped and packed in boxes before storage. When ready for export the decayed fruit is removed and the fruit is regraded and rewrapped. The losses that occur from blue mold are recognized by the shipper to be due principally to the rough handling of the fruit before it is stored; an unwrapped lemon stored under these conditions would shrivel slightly and lose the fine texture of the skin. The very green fruit picked in October is not considered of good storing quality, as it may shrivel while in storage, while the fruit maturing in January and later loses in keeping quality as the harvesting season progresses.

THE COST OF PRODUCING LEMONS IN ITALY.

It is difficult to obtain accurate figures on the cost of producing a crop of lemons in Italy on account of the variable conditions under which the fruit is grown and the lack of information on the part of

the growers themselves. No attempt will be made in this publication to give an itemized statement of cost. An observer may easily gain widely different impressions by questioning producers who work under different conditions and in different parts of the country. In the fall of 1908 the wages of labor used in the groves in different parts of Sicily and on the mainland varied from 40 to 70 cents a day of ten hours. The usual price was about 50 cents a day; a higher figure was found only rarely. In the packing houses the men were paid from 50 to 60 cents a day. A man with a team of oxen was paid $2 a day. The women were paid from 30 to 40 cents a day and occasionally as high as 70 cents, and the boys from 20 to 30 cents. In some sections the daily wage includes a bottle of wine. Where this occurs the wine represents the equivalent of about 6 cents in the wage and is deducted from it. Previous to 1908 the wages were lower, but there is said to be a growing scarcity of labor in Italy on account of the heavy emigration and it was expected by all classes of business men that there would be a further advance in wages in the future.

A fair estimate of the cost of producing a crop on a bearing grove, including cultivation, irrigation, fertilization, pruning, and other operations up to the time of picking, is from $25 to $60 per acre, though the latter figure is unusually high. This does not include taxes or interest on the investment. This estimate is based on the cost of producing the fruit in the larger, well-managed groves. The cost is less in the groves that are not so well managed. In one of the large groves in the Alcantara Valley, near Giardini, the cost of cultivation and pruning in 1908 was 10 cents a tree, fertilizing 10 cents, and irrigation 2 cents, making a total of $25 per acre for 100 trees. This grove was representative of the better groves on the eastern coast of Sicily. The cost of production will probably not equal more than one-half as much as the cost in the United States.

The cost of handling the fruit from the tree to the point of shipment is equally difficult to estimate. It is fair to assume that the cost of the labor used in the different operations will not equal one-half the cost of similar labor in the United States. The investment in the equipment of a packing house is smaller than in California. These general statements are based on the comparative wages paid in the two countries and not on the efficiency of the labor. The Italian lemon box costs about the same as the American box. The freight rate on lemons, per box, from Sicily to New York or Boston was 1s. 3d., or 31 cents, in the fall of 1908. The box is estimated to weigh 82 pounds.

II.—THE BY-PRODUCTS OF THE LEMON IN ITALY.

By E. M. Chace, *Assistant Chief of the Division of Foods, Bureau of Chemistry.*

INTRODUCTION.

The relative importance of the industry which has to do with the utilization of the by-products of lemon culture is controlled, as a whole or in any single district of Italy, by several well-defined factors. Of these, the quality of the fruit is of the greatest importance, for in regions where it is uniformly good the problem of the disposal of the few culls is solved by local consumption. In other regions, however, the nature of the fruit itself practically prohibits its exportation, and it is here that the so-called "by-products" become the source of the chief industry of the district. Where there is any question of the purpose to which the fruit is to be put, the anticipated profits will be the controlling factor and the relative price of citrate of lime and lemon oil will be compared with that of the fresh fruit.

The price of labor and conditions of transportation are also important minor factors, as it is manifestly less costly to sort and pack the fruit than to transform it into oil and citrate, but, on the other hand, it is less difficult to transport these final products than the original fruit, which requires such careful handling and is subject to decay. The financial condition of the operator is also a factor, for the by-products offer a more tempting field for speculation, citrate of lime keeping indefinitely, while large quantities of the oil remain over from crop to crop. Lastly, local custom plays a much more important part than would be possible in this country. Changes in methods of operation are much more conservatively received, and the working classes as a whole do not adapt themselves so readily to new tasks.

GEOGRAPHICAL DISTRIBUTION OF THE BY-PRODUCT INDUSTRY.

In northern Italy one or more of the factors mentioned render the production of by-products unprofitable and it is not until the southern part of the southernmost provinces of the mainland is reached that this branch of the industry begins to flourish. Across the straits of Messina in Sicily it reaches its zenith, and along the southeastern coast of that island it is the principal resource of the people.

In the province of Calabria another essential-oil industry shares the attention of growers and materially lessens both the lemon culture and the production of lemon oil; the manufacture of citrate of lime, however, is relatively increased, as it is also a by-product of bergamot culture. The world's supply of bergamot oil for the manufacture of perfumes comes exclusively from this comparatively restricted region, so that much higher prices are obtained for it than for lemon oil, which has to compete with the output of Sicily. It has been estimated by competent Messinese brokers that only a small percentage (certainly less than 5 per cent) of the total lemon oil production comes from this region.

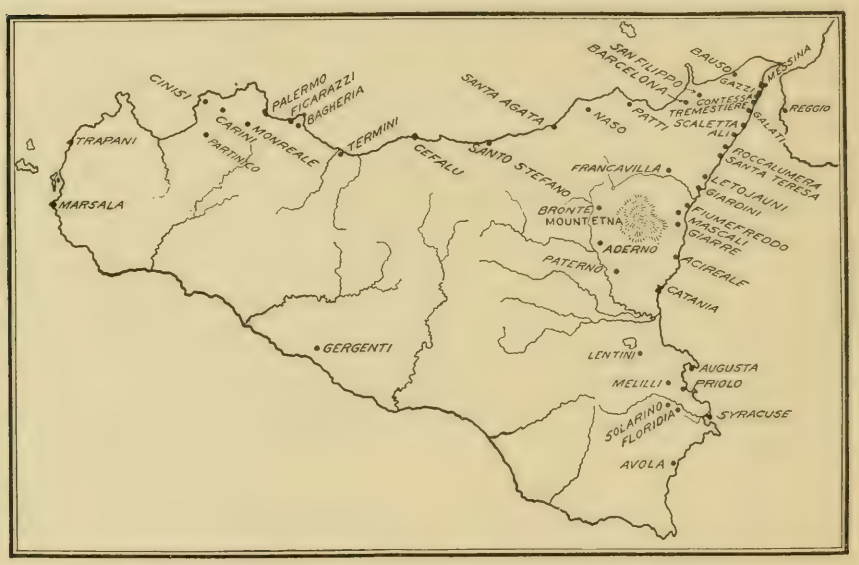

FIG. 4.—Map of Sicily, showing the regions where lemon by-products are prepared.

The adjacent island of Sicily, separated from the mainland by only a few hundred yards at the nearest point, is the largest lemon-growing region of the world. Here the lemon-producing belt lies along two sides of the triangular coast line, interrupted with few exceptions only in the spots where the hills advance into the sea. This belt is naturally divided into four parts, and one of these is best divided again in districting the island. A map of Sicily showing the by-product regions is shown in figure 4.

THE INDUSTRY IN THE ETNA DISTRICT.

The Etna district begins on the south at Catania, a city of considerable importance, second in size in Sicily, around it being clustered several important gardens from which arises considerable trade in both fresh fruit and by-products. The former is exported prin-

cipally to Austrian ports, while the by-products go to Messina for exportation. The city contains but one lemon-oil factory of considerable size, but many smaller ones are situated in the suburbs. These latter places are crowded into the narrow streets and alleys under the most sordid conditions, the fruit being prepared in the street and the oil extracted in the living rooms and stored in the sleeping quarters of the house. The only place given over exclusively to the manufacturing process is the room devoted to the citrate of lime, and even this often serves as a stable. These operators buy a few culls from day to day, every member of the family taking part in the work of converting them into the final products.

In this district the next center farther north is Acireale, a small thriving city, the most important of the by-product industry in the Etna district. There are a dozen or more factories here, and it is also headquarters for the Essential Oil Producers' Association, an organization of comparatively recent formation, the membership of which seems to be confined to producers in the Etna district.

North of Acireale, 6 miles distant, is Giarre, with one factory of fair size and several of minor importance. About 2 miles nearer the foothills of Mount Etna, at the railroad station for Mascali, is a small village called Carrubba, whose inhabitants, men, women, and children, are employed in a group of large factories situated there. One of these factories is the largest and best equipped in Sicily, employing at the height of the season over 300 hands, producing several hundred pounds of oil a day. Even here the advances which have been made do not seem to have changed the character of the methods employed, the improvements often seeming more apparent than real, and being certainly greatly emphasized by the crude conditions surrounding them.

Mechanical carriers are used for conveying the fruit from one part of the factory to the other and for carrying off the waste products, but no devices for halving the lemons or removing the pulp from them have been attempted. A battery of machines for extracting the oil from the peel had, however, been installed, but later abandoned. It is not strange that the device was a failure, for the peel required the same preparation as in the present methods of handling, and each machine needed an attendant, who handled separately every half lemon rind. As the rate of production was not greatly increased, the apparent saving was the difference in cost between the hire of a boy or girl attendant and that of a man sponger minus the cost of power necessary to operate machines. After all, however, the place is exceedingly well equipped when compared with other Sicilian factories, having cement floors and tanks, an electric lighting plant, steam ovens for drying citrate of lime, and many other improvements not usually seen on the island.

The two neighboring factories are of the usual type, but well arranged and roomy, employing about 50 hands each. They produce in the neighborhood of 100 pounds of oil daily.

Several miles northwest of this point, on the first of the foothills of Mount Etna, is the town of Mascali, containing several small factories of minor importance, drawing their fruit from the upland valleys of the vicinity. The other two centers in the district are Fiumefreddo and Giardini. The former contains several factories of a daily capacity of 50 to 100 pounds of oil; the latter, one large factory and several very small ones; there being in addition several small places between the two towns. Giardini is the northern limit of the district and draws its supplies from the south, being cut off from the Messina district on the north by a steep range of hills, over which hauling is difficult even on the fine military road which skirts the coast. Fiumefreddo is 6 or 7 miles farther south and is surrounded for miles on all sides by lemon gardens. The whole region from Catania to Giardini lies at the foot of Mount Etna, many of the fruit orchards being on its decomposed lava beds.

Oranges are also grown in this district, but are as a rule farther inland in the foothills. Aderno, Paterno, and Bronte, situated well up on the slopes of Etna, have considerable of this trade, as has Francavilla, farther north, nearer Giardini, the large factory at the latter place producing considerable quantities of both sweet and bitter orange oil from the fruit grown here.

The season begins in the Etna district in December and is practically over by April 1, although a few small operators continue into May. As the growing of Verdelli lemons is less practiced in this region than in the Messina district or in parts of the north coast, the inducements for summer work are not the same. The output of the district is marketed at Messina, being shipped to that point by rail, the exportation of oil and citrate of lime from Catania being less than the production of that city alone.

THE INDUSTRY IN THE MESSINA DISTRICT.

The Messina district, the second largest in Sicily, is practically a continuation of the Etna district on the south. The lemon-producing land lies along the coast, extending into the few valleys which run back between the hills as in that district. The soil, however, is probably quite different, as it is much farther from Mount Etna, no lava streams having entered the section for many hundred years.

The largest center at the southern end of the district is Santa Teresa, from which the oil of the neighboring town Roccalumera is also shipped. There are eight or more factories in the two places, one of which is considerably above the average size, employing a hundred hands or over, the others varying from those employing

less than a dozen to those which have upward of fifty. Northward toward Messina, the next center of importance is Scaletta Zanglea, where are located three or four factories of very small size. At the northern end of the district, from Galati to Messina, the coast belt is much narrower than toward the south; the towns here stretch continuously along the military road, there being scarcely a visible boundary between them. When riding along this road the whole region seems an extension of the city of Messina.

The chief centers are Galati, Tremestieri, Mili, and Contesse, all small towns having direct railroad connections with the city. The factories are, taken as a whole, better equipped than elsewhere in the island. All are of moderate size, some employing less than twenty hands, while one, with over two hundred, is second or third in size in Sicily. This factory is one of the very few to produce concentrated oil by fractional distillation of the usual product. Owing to the size of the factories and the narrowness of the coast strip here, a large quantity of the fruit consumed is drawn from farther south, and during the bergamot season from Calabria, on the mainland.

Messina itself is hemmed in on all sides by high hills upon which no lemons are grown; fruit in large quantities must therefore come from some little distance. For this reason there is but one factory of any considerable size in the city; it employs, however, over two hundred hands, being situated on the north side of the city in an isolated group of gardens.

Messina, like Catania, contains many very small places where oil is made in the dwellings of the lower classes, the output in any single instance being small, but the total of some importance. There was also at one time a quantity of by-products produced here from the culls of stored fruit; this practice has, however, almost ceased at present, as storage fruit has given way before the Verdelli lemon.

On the north coast, not far from Messina, are two centers of minor importance, Bauso and Rometta. There seems little reason for classing them with the remainder of the Messina district except for the fact that they employ methods of production similar to those used on the south coast, while the center nearest them on the north coast employs a somewhat different process in obtaining oil. Undoubtedly, however, as far as the oil is concerned its composition here is more nearly like that of the north coast, no matter what process is used in its production. The factories in these towns are quite small, especially at Rometta, Bauso containing one of the average size, employing nearly fifty hands.

As in the Etna district, the produce of the entire Messina region is disposed of through Messina brokers. The season also is the same as in that district.

THE INDUSTRY IN THE PALERMO DISTRICT.

Palermo, the third district of importance, is the most westerly of the five. As in the other north-coast regions, lemon cultivation occurs in large isolated groups of orchards, with the exception of the Conco d'Oro, where the whole valley is given up to it. This valley is of exceptional fertility, and it is said that at one time considerable sugar cane was raised here. The fruit being above the average quality, the greater part of it is shipped fresh. The culls for by-products go both to Palermo and to the small city of Monreale, beautifully situated above Palermo in the hills. Here are some half dozen poorly equipped factories of small size, employing from a dozen to thirty hands each.

Palermo itself is the largest city of Sicily and contains several important factories, situated largely in the suburbs; the output of oil is not, however, larger than that of some of the small towns of the south coast. Information about the factories here is much harder to obtain than in other parts of Sicily; there are at least six of average size, the city being free from factories of the smaller type such as are found in Catania and Messina.

Toward the east, the principal center is Ficarazzi, where there are several factories, one of which may be said to be large. There are also other towns to the west of Palermo which contain manufacturing plants, but they are small and relatively unimportant. At Partinico, on the Trapani railroad line, are two or three, at Carini one, and at Cinisi another; taking it all in all, they are the crudest of the island.

While this district produces a large quantity of oil and citrate of lime, the industry is not so well developed as in the two districts already described, these commodities here being in every sense of the word by-products.

The production of summer lemons is universal in this region and affects to a considerable extent the composition of the essential oil. This is probably due to admixture of oil produced from the Verdelli lemons left upon the trees until the following season. Ordinarily the amount thus produced is small; when, however, the price of summer fruit is low it is very often left unpicked until the following natural crop is gathered, when it is sorted out with the other culls. In some factories this fruit is discarded, no attempt being made to produce oil from it. In the majority of cases, however, it is worked up as usual. It would seem that the former is far the better policy, as the yield both of oil and of citrate of lime are extremely low, added to which is the further disadvantage of the inferiority of the resulting oil. Where this fruit forms a considerable proportion of that

from which it is being produced the resulting product is not marketable except in admixtures with normal oil.

The season begins here later than in any of the other districts, often two months later than at Syracuse, and extends later into the warm weather, the month of June often finding several factories still in operation. Although this district contains the largest seaport and city of commercial importance in Sicily in the city of Palermo, only a comparatively small quantity of the by-products is shipped from that point, this exportation going to England, that coming to the United States being confined to fresh fruit.

THE INDUSTRY IN THE SYRACUSE DISTRICT.

The fourth by-product district is on the opposite side of the island, southeast of Palermo, and is but slightly less important than that center. The Syracuse district differs in many ways from the others of Sicily; the country not being mountainous, the fruit is cultivated farther inland than usual and the problem of irrigation is more difficult. Lemon culture is not the chief occupation here, for the country was one of the finest wheat-growing regions of ancient times, and at present besides this cereal both almonds and grapes are extensively cultivated.

The climate is very mild, the gathering of lemons beginning several weeks earlier than in the other districts. October 15 to April 15 is a liberal estimate of the manufacturing season, while fifteen days might be cut from each end and more nearly represent the actual fact.

The district contains several isolated centers of production, the gardens not being continuous, as in the lemon belt proper, but clustered in large groups about the several towns. Three of these centers are of considerable importance, the cities of Syracuse, Floridia, and Avola, all containing six or more factories and each employing 20 hands or more.

At Syracuse there are no factories on the island which forms the old city, all being on the mainland in the newer suburbs. Comparing favorably in size with the average factories in other districts, they are in equipment above those at Palermo, but not so well equipped as those near Messina. Floridia is some 12 miles inland from Syracuse, situated in a very fertile valley of lemon groves, the half dozen factories here varying in size, two being of considerable importance; all are, however, devoid of mechanical improvements. The output of this town is carted to Syracuse, as it has no railroad connections.

South of Syracuse city no lemons are grown until Avola, 15 miles distant, is reached. Here is situated another large group of orchards; the factories, as usual clustered about the town itself, are

below the average size and have no special equipment. Some orange oil is prepared in this district and large quantities of peel are dried and sold for the preparation of the liqueur curacao.

The other centers in this district are Augusta, with one factory of average size; Priolo, with two small places; and Melilli, with one. Augusta is 18 miles north of Syracuse, on the coast, and is the center of the salt industry; Priolo is between Syracuse and Augusta, some miles from the railroad, while Melilli is farther inland, situated well up in the low hills.

The lemon products of the district find their way to market through Messina, with which there is direct railroad connection.

THE INDUSTRY IN THE NORTH-COAST TOWNS.

The remaining district to be considered is the heterogeneous collection of towns on the north coast. Here, again, as in Palermo and Syracuse, the cultivation of the lemon takes place in isolated groups of orchards around the central towns, the country being very mountainous and having no cultivated strip of coast land, as on the south. The fruit is grown in the valleys between the spurs of hills, all of the large towns being near the Messina-Palermo railroad line, which winds along the seacoast.

By far the most important center, in fact the only important one of this region, is Barcelona, a small inland city not far from the seaport of Milazzo. Here are some three factories, employing from 30 to 50 hands each, and a few more of smaller size, all without mechanical equipment. The methods employed are, as has been stated, similar to those of the Palermo district, the old method of production being used and distilled oil manufactured from residues.

The small city of Patti, the next largest by-product center, is west of Barcelona, 2 miles from the railroad station of the same name. There are but two factories here, both employing approximately 30 hands and, as at Barcelona, producing considerable sweet and bitter orange oil.

Farther west there are no other factories until Capo d'Orlando is reached, at which place are several of small size, which is also the case at Santa Agata di Miletello. The factories in all of these places use the so-called new or two-piece method of manufacture, which is peculiar, inasmuch as they are situated between two larger districts using the other method. At Santa Agata di Miletello the factories do not produce citrate of lime, the lemon juice being concentrated in copper kettles and sold to liqueur and bitters manufacturers in northern Italy.

The commerce of the north-coast towns, as far as lemon by-products are concerned, is carried on through Messina, although there is a thriving local seaport town, Milazzo. While the district covers

a much greater territory than that covered by either the Palermo or Syracuse districts, it produces less oil and citrate than either. The season is more nearly like that of the Palermo district, although manufacturing begins somewhat earlier and ceases sooner than in that district.

MANUFACTURE OF BY-PRODUCTS.

There are two chief by-products of lemon culture—the essential oil of lemon and citrate of lime; besides these, lemon peel in brine and concentrated lemon juice are of lesser importance. Oil of lemon is used very largely for flavoring purposes. It finds application also in perfumes and to a limited extent in pharmaceutical preparations; the greater part of that imported into this country, however, is used in the preparation of the ordinary extract of lemon, well known to every housewife. Citrate of lime, or, more properly, calcium citrate, is an intermediate product in the manufacture of citric acid. In the lemon juice itself the acid occurs in the free state, together with sugars and mucilaginous bodies. It is in order to free it from these that it is combined with lime, for the compound thus formed is insoluble and precipitates from the juice, being finally separated by filtration. This product must then be again treated in order to free it from lime and obtain the citric acid once more in the free state. There are no factories in Sicily for this purpose, although the Italian Government was, before the recent earthquake, making efforts to establish a plant by subsidy. The product is now shipped to Germany, England, and the United States, where the lime salt is decomposed with sulphuric acid, filtered through boneblack, and crystallized from solution in water. The process is one of some difficulty, considerable loss arising from the decomposition of the citric acid by the sulphuric acid present.

The salting of the lemon peel is usually confined to those districts of Sicily where the towns are upon the seacoast situated near sloping beaches, so that sea water is easily obtainable. It is not usually packed in the interior, although a few towns near Messina have some little trade in this line, the product being repacked in that city. Producers in Sicily claim that there is a demand for three separate kinds of stock; first, that from which no oil has been removed; second, that which contains approximately half the oil; and, lastly, a completely exhausted product. All classes are consumed in the bakers' and confectioners' trades. Where the rinds are to be used for packing, the lemons are divided lengthwise, the pulp removed in the usual way, and the peel packed by hand as firmly as possible in large hogsheads, which are afterwards filled with sea water and reenforced by the addition of salt.

The production of concentrated juice is not extensive, the factories being small and the methods of evaporation extremely crude. In

those at Santa Agata di Miletello the juice is pressed from the pulp and filtered, as in the manufacture of citrate of lime, and then pumped into shallow tanks supported over a crude fireplace. Here evaporation takes place over a wood fire until the required consistency is obtained, this point being ascertained by cooling a portion of the juice and inserting a spindle. The final product, a very dark semi-sirup, of acid, bitter, and smoky taste, is sold to liqueur and bitters producers in northern Italy. Besides the two factories at Santa Agata di Miletello, there are one or two on the Calabrian mainland. Altogether the industry is of minor importance.

EQUIPMENT OF BY-PRODUCT FACTORIES.

It has already been hinted that in the great majority of cases the factories in Sicily are very poorly, even crudely, equipped, the nature of the operations which take place requiring but very simple apparatus. In the preparation of oil, machinery is not used except in the few factories which are situated in Calabria.

For the manufacture of citrate, a crusher, as shown in Plate IV, figure 1, a filtering device for juice and another for citrate, a precipitating tank supplied with a heating coil, an oven or heating room, and a small juice pump only are necessary. This apparatus is usually arranged to fit into quarters originally intended for other purposes; the crusher and filter presses on substantial foundations near the room where the cutting of the fruit takes place, near the latter a juice tank and pump, while the precipitating tank is also near by, as the pumping is usually done by hand in the heating room wherever convenient.

In many of the smaller factories a loft is floored off and the space thus provided used for extraction of the oil, the room often being scarcely 6 feet high in the center, dark, and ill ventilated. On the north coast, where the work takes place at night (from midnight to 8 or 9 o'clock in the morning), this place also serves as sleeping quarters for the sponge men. The custom of preparing the oil at night seems confined to the Palermo and north-coast towns. The explanation given for this method of operation is that the sunlight has a deleterious effect upon the oil, but a more probable cause is the fact that the sponging operation can take place at night with less trouble than any of the other processes in by-product manufacture and that the same workmen can thereby work during both daylight and darkness.

PREPARATION OF THE FRUIT.

The preparation of the fruit differs somewhat in the different districts, and while the variation seems slight it undoubtedly affects the length of the operation and perhaps the quality of the oil produced. In the Syracuse, Etna, and Messina districts and in Patti and Santa Agata di Miletello, north-coast towns, a method known as the "two

piece" is used. In Palermo and Barcelona the process used is called "three piece," although some factories in the latter city use the other method. The difference between the two lies in the manner of removing the rind from the fruit. In the former the lemon is halved and the pulp removed from these halves; in the other the peel is pared off in three longitudinal strips. The three-piece method of preparing the fruit is shown in Plate V, figure 1. When the fruit arrives at the factory it is dumped into large bins, around which sit the cutters, who divide the lemons in halves or pare them, according to the method used. An ordinary cheap kitchen paring knife is used for this purpose, the operators being women, girls, and boys on the south coast; on the north coast women and children are seldom employed. The work is carried on very rapidly where the fruit is halved crosswise, the lemon being cut and tossed into the tub with a single motion of the arm. Where the peel is to be salted down, the fruit is divided from end to end, and the time consumed is relatively longer, as is also the case where it is pared. The next step in the process is naturally omitted where the latter method is used. The half lemons are thrown upon shallow troughs, on each side of which stand the operators provided with baskets for holding the peel. The instrument used consists of a sharp, slightly concave disk firmly fastened on the end of a stout sickle-shaped wire, provided at the opposite end with a wooden handle. The disk is skillfully slipped between the pulp and rind of the lemon, held in the left hand, and forced toward the end with a circular motion of both the instrument and fruit. When sufficiently far advanced, a quick jerk removes the pulp, the separation being complete and the rind unbroken.

The operators are usually paid by the basket of resulting peel, the women making from 20 to 40 cents a day, while the children, who do the cutting, rarely make over 15 cents, often as low as 5 cents. Where the lemons are pared the separation is much less complete, there being always considerable pulp left on the rinds and some little rind at the ends of the pared fruit. As a result of this, some little lemon juice becomes mixed with the extracted oil, and after the extraction of the oil from the peel the latter has to be mixed with the fruit pulp in order not to lose the considerable portion of the part of the fruit clinging to it.

EXTRACTION OF THE ESSENTIAL OIL.[a]

In both methods of operation the peel is thrown into large wicker baskets, which, when full, are dipped into a reservoir of cold water and thoroughly shaken to remove the excess. This washing is said

[a] See also the article by the same author, entitled "The Manufacture of Flavoring Extracts," in the Yearbook of the Department of Agriculture for 1908, pp. 333–342.

to wilt the rind and render a complete extraction of the oil possible. However this may be, it is certain that fruit treated in this manner and allowed to stand for several hours yields relatively more oil than that worked up immediately after separation from the pulp. At this stage, the pulp and peel having been separated, the former is sent to the crusher to be converted finally into citrate of lime, the latter to sponge men, who extract the oil.

The extraction or sponging process is not essentially different with the different forms of peel, the operators sitting upon low stools with an earthenware bowl between the feet, a pile of peel in front of them, and a basket for the exhausted material at one side. The bowl is about a foot in diameter, provided with a deep lip, directly beneath which is a small, round, concave depression which serves when the bowl is tilted forward, in pouring out its contents, to hold back the settlings of juice and precipitated matter. Across the top is placed a stick so notched as to fit tightly on the sides; resting upon it are the sponges, which differ somewhat according to the manner of preparing the peel. Where the fruit is cut crosswise, a large, flat sponge is surmounted by a smaller concave one, shaped somewhat like a brimless slouch hat, the half lemon being placed within this sponge when pressed. When the lemon is cut in the other direction, a large, heavy sponge rests upon the flat one and the fruit is pressed, colored side down, into it. This method is also followed where the rind has been pared from the fruit. With the first method the half rind is held in the right hand between the thumb and first two fingers and inserted in the wide aperture of the concave sponge, whereupon the latter is pressed upon with the left hand, the weight of the body being thrown into the motion. The pressure is relieved, the peel turned partly over with the right hand, and the pressing repeated. The same operation is carried on once or twice more, the rind thus receiving three or four pressings. Where the concave sponge is not used, the peel or slices are pressed face downward on the other sponge with the right hand, the left being used to keep the sponge in place, the same amount of force and number of pressings being required in either case.

The sponging process is somewhat varied where the three-piece method is used, owing to the quantity of pulp left adhering to the rind. A shallow, glazed bowl is placed upon the one ordinarily used and the notched stick fitted to it so that the mixture of juice and oil is received directly here. At the end of the operation the sponges are thoroughly squeezed out by hand and the lemon oil separated from the juice by tilting forward the glazed bowl over the other and violently blowing the breath upon the surface of the mixture until the oil has been carried over into the lower bowl. In this operation some juice and residue are found mixed with the oil, and this is sep-

arated finally in the larger bowl by carefully tilting forward and repeating the blowing operation. The small amount of juice and residue now present is caught by the depression in this bowl and the oil is received in a measuring bottle. The operation where the two-piece method is used is very similar; the oil and what little moisture and residue are extracted are caught in the earthenware bowl and separated as indicated.

The oil in either case is allowed to settle for twenty-four hours or longer, filtered through paper, and stored in large copper containers; that made by the three-piece method is said to keep longer without becoming turbid.

TREATMENT OF THE RESIDUES.

The treatment of the residues resulting from both methods is different; with the two-piece method they are passed through a conical cloth filter and the oil and water received in an earthenware bowl, where they are separated in the usual way. The filter is tied at the top and placed under a hand press, where the last traces of oil and water are expressed. The residues from the three-piece process, which are relatively greater in amount than by the other method, are placed in small copper stills, diluted with water, and distilled. The still is made in two parts, the pot being about 2 feet high, narrowing abruptly to a 3-inch aperture at the top, over which the condensing part fits tightly, the joint being cemented each time with clay. The latter part is a basin, whose straight sides are continued a short distance beyond the concave bottom, after which they converge similarly to the sides of a funnel. It is provided with two spouts, one of which enters under the bottom into what becomes the condensing chamber of the still; the other enters above and is used to draw off the water placed in the basin in order to cool the vapor coming in contact with it during the dis-

FIG. 5.—A lemon-oil still used on residues, Palermo. The oil produced is inferior to the hand-pressed product.

tillation. The condensation is further aided by wrapping the other spout with rags, over which the attendant pours cold water from time to time. A still is shown in figure 5.

The oil obtained by this process is water white, of disagreeable odor and abnormal chemical characteristics; having no sale in the pure state it is invariably mixed by either producer or broker with the hand-pressed product. The filtration method undoubtedly gives the best results, for if the residues are treated immediately the resulting oil can scarcely be distinguished from the original. Distilled oil is produced only at Barcelona and Palermo; in all other districts the residues are filtered.

MACHINE-MADE ESSENTIAL OIL.

The manufacture of lemon oil by machine is confined to the mainland of Italy, in the province of Calabria. As has been said, large amounts of bergamot oil are made here, and it is with the machine used in this industry that lemon oil is produced. The bergamot is shaped more like an orange than a lemon, being nearly round, so that the apparatus has to be slightly modified in order to use it on the latter fruit. The modification consists in removing the flat disks and substituting concave ones for them.

The machine itself, shown in Plate VI, figure 1, consists of a stand supporting two upright arms united by a crossbeam at the top. On the inside of one of these uprights is hung a large cogged wooden fly wheel geared against a cylinder, the sides of which are upright spokes fitting into the cogs of the fly wheel. To the under side of this cylinder is bolted a corrugated disk, shown in Plate VI, figure 2, fitted so as to revolve above a like stationary one at the bottom of the machine. An arrangement for raising and lowering the upper disk is provided for by an arm fastened to the cylinder and extending over a crosspiece at the rear. This arm is so weighted as to regulate the pressure brought to bear upon the fruit which is placed between the upper and lower disks. When it is lowered, the upper disk is raised and the lemons, which must be of uniform size, are placed within. The lever is then raised, lowering the disk upon the fruit, and the outside fly wheel is turned by hand. After two minutes it is stopped and the fruit removed, each lemon being carefully wiped off with a sponge. The grated rind and oil are received in a large pan set beneath the machine and subsequently filtered through cloth filters, the residue being placed under hand presses to express the last traces of oil and moisture.

Oil manufactured in this way is not in the least inferior to the hand-pressed product and has the added advantage of a much richer color, being used chiefly for the purpose of bringing up the color of

the latter. The machine is not used on lemons until after the close of the bergamot season, fruit ripening before that time being sold to Sicilian buyers.

CITRATE OF LIME.

After the pulp of the lemon has been removed from the rind it is conveyed to a crusher, sometimes power-driven, but in a vast majority of factories run by hand. A crushing machine is shown in Plate IV, figure 1. The ordinary type consists of a hopper leading into wooden rollers and a small chute for carrying off the crushed pulp, the whole being placed over, or very near, a juice tank, into which the drippings flow. The crushed pulp is shoveled into large, circular, straw filtering mats and pounded down firmly with wooden rams. These mats are closely woven of coarse straw and have a circular opening at the top; after being filled they are placed one upon another in stacks of 4 to 12 under hand presses of large size. The presses are set, often by the aid of a windlass, and the combined pressing and filtration proceeds until the flow of juice ceases, the presses being set down several times during the operation. A press and filtering mats are shown in Plate IV, figure 2. The juice is led into the juice tank, from whence it is pumped, usually by hand, into a large vat provided with suitable heating arrangements consisting of direct fire, steam coil, or, in one or two instances, leading steam directly into the juice. In this tank the acidity of the juice is neutralized by means of lime water, the point of neutrality being ascertained by the use of litmus paper, and after heating for several hours the juice is run off into the filtering tank while still hot. The latter tank is provided with a false bottom of wooden latticework, over which is spread a special filtering cloth; the citrate of lime, which is deposited in a voluminous white powder, is retained by this cloth, while the waste liquor runs through and is discarded. When this liquor has sufficiently drained off, the deposit is shoveled into a small filtering bag and placed in stacks beneath a small press, where the excess is further removed. It is usually readily removed from these sacks to iron pans in which it goes to the drying oven. This oven is a small room, ventilated at the top, around the sides of which are built tiers of iron frames for holding the pans. In the center of the room is a gigantic charcoal burner, which supplies the heat for the evaporation, from six to forty-eight hours' drying being necessary, depending upon its size. The thoroughly dried cake, containing over 60 per cent of citric acid, is broken into small pieces and packed in hogsheads holding about 675 pounds each. An interior view of a by-product factory is shown in Plate V, figure 2.

The method of disposing of this product is very similar to that used with essential oils; small or large lots are offered to brokerage

firms, accompanied by a certificate of analysis showing the actual content of citric acid. Exportation is nearly always through one of these houses, and there seems to be little or no effort to market the output cooperatively. The product is purchased on the citric-acid content by the large chemical supply houses in Germany, England, and the United States.

COST OF PRODUCTION OF BY-PRODUCTS.

The quantity of the by-products obtained from a given number of fresh lemons will depend upon the quality of the fruit, the season of the year, the time which has elapsed between the gathering and working up, and the efficiency of the latter process. When allowed to ripen upon the tree, the lemon loses a considerable part of its acidity and the oil is also less in quantity and of an inferior grade. Where the fruit is broken or bruised in handling, the yield of oil is diminished, and this is also the case where a number of days are allowed to elapse between picking and working up. The content of citric acid is not lessened by these faults, however. On the average quality of fruit, 100 pounds of oil and 675 pounds of citrate of lime, containing 430 pounds of citric acid, can be produced from 100,000 lemons. The average price for these substances varies from $80 to $100 for the oil and $75 to $95 for the citrate. At the time of writing, owing to the recent earthquake disaster in Sicily, the prices are firm and somewhat higher.

The cost of production is very difficult to estimate and will, of course, vary in every locality and almost with every factory. In the consular reports of the late Doctor Cheney he estimates the average value of lemons to the grower in Sicily at $150 per 100,000. The fruit going for by-products is the lowest grade, however, and will not average over $100 per 100,000, leaving a gross profit to the by-product producer of from $50 to $100. One sponge man can produce between 2 and 3 pounds of oil per day, for which he receives about 30 cents, making the cost of extracting the oil from 100,000 lemons from $10 to $15. Other processes about the factory are much cheaper, and it would seem, at the usual wages of workmen, that $5 to $10 additional would be a liberal estimate for other expenses, leaving a profit of from $30 to $70 jointly on 100 pounds of oil and a pipe of citrate of lime. It is believed that the above estimates are very conservative and that the actual profits are considerably higher than the figures given.

PLATES.

DESCRIPTION OF PLATES.

PLATE I. Lemon groves on the Amalfi coast. Fig. 1.—Terraces of lemon trees on the mountain side near Majori. Masonry walls are built to keep the land from sliding. Fig. 2.—Terraces of lemon trees rising from the sea. The larger trees are olives. There is a trellis over each terrace for frost protection.

PLATE II. An Italian and an American lemon grove compared. Fig. 1.—One of the better types of groves at Mascali, Sicily, showing the high-headed trees, a distributing furrow between the rows, and basins around the trees. Fig. 2.—A grove of low-headed trees in California.

PLATE III. A lemon-picking scene and a packing-house interior. Fig. 1.—Picking and grading the fruit, Palermo. The lemons are being graded roughly for by-products and for export. Fig. 2.—Interior of a packing house at Catania, showing the padded bins used in grading and packing.

PLATE IV. Preparation of citrate of lime. Fig. 1.—A crushing machine. Mills are not used for extracting lemon juice in Sicily. Fig. 2.—A lemon-juice press. This press acts also as a filter.

PLATE V. Preparation of lemon oil. Fig. 1.—Paring lemons, 3-piece method, Palermo. This method is used only in the Palermo district and at Barcelona. Fig. 2.—Interior of lemon by-product factory, Syracuse. This shows one of the few factories in Italy using mechanical devices in handling the fruit.

PLATE VI. Lemon-oil machinery. Fig. 1.—A lemon-oil machine used in Calabria. This machine is confined in its use to the Calabrian district, where it is also employed in the production of bergamot oil. Fig. 2.—Disks used in Calabrian machines. The surface of these disks is not unlike that of a burr mill.

FIG. 1.—TERRACES ON THE MOUNTAIN SIDE.

FIG. 2.—TERRACES RISING FROM THE SEA.

LEMON GROVES ON THE AMALFI COAST.

FIG. 1.—A GROVE AT MASCALI, SICILY, SHOWING A DISTRIBUTING FURROW AND BASINS AROUND THE TREES.

FIG. 2.—A GROVE OF LOW-HEADED TREES IN CALIFORNIA.

AN ITALIAN AND AN AMERICAN LEMON GROVE COMPARED.

FIG. 1.—PICKING AND GRADING THE FRUIT, PALERMO.

FIG. 2.—INTERIOR OF A PACKING HOUSE, CATANIA.

A LEMON-PICKING SCENE AND A PACKING-HOUSE INTERIOR.

Bul. 160, Bureau of Plant Industry, U. S. Dept. of Agriculture.

FIG. 1.—A CRUSHING MACHINE.

FIG. 2.—A LEMON-JUICE PRESS.

PREPARATION OF CITRATE OF LIME.

FIG. 1.—PARING LEMONS, 3-PIECE METHOD, PALERMO.

FIG. 2.—INTERIOR OF LEMON BY-PRODUCT FACTORY, SYRACUSE.

PREPARATION OF LEMON OIL.

Bul. 160, Bureau of Plant Industry, U. S. Dept. of Agriculture.

FIG. 1.—A LEMON-OIL MACHINE USED IN CALABRIA.

FIG. 2.—DISKS USED IN CALABRIAN MACHINES.

LEMON-OIL MACHINERY.

INDEX.

Page.

Acid, citric, not manufactured in Italy 15, 43
recovery from citrate of lime, process in Italy 43
tariff rates, United States 19
Ammonia sulphate as source of nitrogen for lemon fertilizing 23, 25
Ashes, fertilizer for lemon gardens 25
Barcelona, Sicily, lemon-oil factories 42
Basin irrigation, lemon gardens, Italy 27
Bastardi lemons, description 22
Basterdoni lemons, description 22
Bergamot, description and extraction of oil 48
oil, manufacture, Calabria 36, 48
world's supply from Calabria 36
Bianchetti lemons, description 22
Bone meal, fertilizer for lemon gardens, Italy 25
By-products, lemon, cost of production in Italy 50
exports from Italy 15–19
factories, location and description 35–43, 44
grades of fruit used in Italy 15, 21, 31, 39, 40
in Italy, *paper* 35–50
industry, Italy, geographical distribution 35–43
manufacture and disposal in Italy 43–44
quantity of fruit used in Italy 10
tariff rates, United States 19
Calabria, bergamot oil manufacture 36, 48
lemon by-product industry 8, 15, 36, 48
Calcium citrate. *See* Lime, citrate.
Carrubba, lemon-oil factories 37
Catania, lemon growing 8, 9, 20, 23
oil factories 37
Chace, E. M., paper entitled "The by-products of the lemon in Italy" 35–50
Cheney, Dr. Arthur S., collection of statistics in Italy, 1908 ..... 10, 27, 50
Citrate of lime. *See* Lime, citrate.
Citric acid. *See* Acid, citric.
Citron and lemon juice, concentrated, exports from Italy, 1898–1908 17–18
raw, exports from Italy, 1898–1908 18
Citrus bigaradia, use as stock for lemon grafting in Italy 24
fruit by-products, tariff rates, United States 19
peel, exports from Italy, 1898–1908 18–19
preparation for by-product manufacture in Italy 44–45
trees, Italy, number, estimate 7
fruits, essential oils, exports from Italy, 1898–1908 16–17
Conco d'Oro, lemon growing 9, 40

Page.
Cost of producing lemons in Italy 32–33
Earthquake, Messina, destruction of lemons and citrate of lime stored for shipment 20, 30
Etna district, lemon-oil factories, location and description 36–38
Europe, imports of lemons from Italy by different countries, character of fruit 21
Exports, lemon by-products, from Italy, 1899–1908, 1894–1908, and 1900–1908 15–19
lemons, from Italy, 1898–1908, percentage to United States 11
principal sources 21
Etna district, Italy, lemon by-product industry 36–38
Factories, lemon by-product, Italy, equipment 44
oil, Sicily, description and location 35–43, 44
Fertilizers, commercial, introduction into Italian lemon gardens 25
for Italian lemon gardens 23, 25–26
Frost, protection of lemon trees in Italy 8, 27–28
Fruit stored in Messina, destruction by earthquake, 1908 20
See also Citrus, Lemon, Orange, etc.
Furrow irrigation, lemon gardens in Italy 27
Gardens, lemon, care and management in Italy 24–30
description, size, number of trees, and yield in Italy 8, 23–24
Grading lemons, Italian methods 31–32
Grafting lemons, Italian method 24
Groves, lemon. *See* Gardens.
Gum disease, resistance of bitter orange 24
Harvesting lemons, Italy, seasons and methods 20, 30–31
Imports, lemons, into United States, from Italy, 1898–1908, ports of entry and of export 11–13
Insects, scale, control by pruning methods, Italy 25
Introduction to paper on "The by-products of the lemon in Italy" 35
"The Italian lemon industry" 7
Irrigation, lemon gardens, Italy 26–27
Italy, by-products of the lemon, *paper* 35–50
lemon industry, *paper* 7–33
See also Lemons.
Juice, lemon and citron, concentrated, exports from Italy, 1898–1908 17–18
raw, exports from Italy, 1898–1908 18
concentrated, manufacture and use 42, 43–44
Labor, cost, lemon oil factories, Italy 44, 50
lemon industry, Italy, scale of wages, men, women, and boys 33
Lava beds, Mount Etna, lemon growing 8, 23
Lemon and citron juice, concentrated, exports from Italy, 1898–1908 17–18
raw, exports from Italy, 1898–1908 18
by-products in Italy, *paper* 35–50
See also By-products.
crop, handling, selling, harvesting, sorting, packing, and shipping, Italy 28–32
Italy, 1907, estimate 10
gardens, Italy, fertilization, irrigation, pruning, etc 23–26
growing, Italy, cost per acre, estimates 33
propagation, pruning, tillage, irrigation, etc 24–30
regions, Italy 7–10, 23
industry, Italian, article by G. Harold Powell 7–33
commercial importance 10–11
extent and location 7–10

Page.
Lemon irrigation, Italian methods 26–27
oil. *See* Oil, lemon.
packing house methods, Italy 31–32
peel, exports from Italy, 1898–1908 18–19
salting 43
pulp, use in manufacture of citrate of lime 46, 49–50
residues, treatment 47–48
shipping centers, Italy 10, 12–13, 20
trees. *See* Trees.
Lemons, Bastardi, description 22
Basterdoni, description 22
Bianchetti, description 22
classification based on time of ripening 22
cost of production in Italy 32–33
domestic consumption, estimate 10
exported to United States from Italy, superior grades 21, 31
exports from Italy, 1898–1908, percentage to United States 11
foreign, distribution in United States 13
methods of handling in United States 13–15
freight rates, Italy to United States 33
grades sent to different markets 21, 31
harvesting, seasons, and methods 20, 30–31
imports into United States, with ports of entry and ports of export 11–13
Italian, handling in the United States, buying and selling 13–15
Italy, character of fruit exported to different markets 21–22
grown in different localities 21
fertilizing 25–26
irrigation 26–27
propagation 24–25
protection against frost 27–28
pruning 25
season of ripening 20
tillage 25
Limoni, description 22
Maggiolini 22
packing in Italy, methods 31–32
peeling for oil extraction, Italy, methods and cost 44
picking in Italy, methods 30–31
preparing for oil extraction, Italy 44–45
price per thousand in the gardens, Italy 30
ripening season, harvesting, and shipping in Italy 20
selling the crop in Italy, methods 28–30
standard weight per thousand 29
tariff rates, United States 19
terms applied to fruit ripening at different periods in Italy 22
value to growers, Italy 30, 50
Verdelli, description and methods of production 22–23
Lime, citrate, exports from Italy, 1899–1908 15
imports into United States, 1894–1908 16
manufacture, amount of fruit used, and product, 1907, Italy 10
Italy, details 43, 49–50
Messina, destruction by earthquake, 1908 30
prices in Italy 50
sale in Italy, methods 49–50
source of citric acid 15, 43

Page.
Limoni lemons, description ... 22
Maggiolini lemons, description ... 22
Majori lemons, growing under trellises, Italy ... 28
Manure, composted, use on lemon gardens, Italy ... 23, 25
green, value in lemon gardens, Italy ... 26
quantity per tree in lemon gardens, Italy ... 26
use in lemon gardens, methods of application, Italy ... 26
Messina, destruction of lemons and citrate of lime by earthquake ... 20, 30
district, Italy, lemon by-product industry ... 38–39
lemon export trade ... 10, 12–13, 20, 21, 38, 39, 42
growing ... 8, 9, 10, 20, 21, 23
Mount Etna lava beds, lemon growing ... 8, 23
Naples, lemon industry ... 8, 12–13
Nitrate of soda. *See* Soda.
Oil, bergamot, manufacture and machine extraction, Calabria ... 36, 48
See also Oils, essential.
lemon, distilled, inferior quality ... 48
essential, extraction, Italy ... 45–47
machine-made, Italy ... 48–49
exports from Italy, 1900–1908 ... 17
extraction, night work, Italy, reasons assigned ... 44
process, Italy ... 45–47
factories, Sicily, description, location, and equipment ... 35–43, 44
imports into United States, 1898–1908 ... 17
machine-made, Italy ... 48
prices in Italy ... 50
See also Oils, essential.
orange, manufacture, Sicily ... 38, 42
See also Oils, essential.
residues, treatment ... 47
Oils, essential, extraction process, methods in Italy ... 45–48
from citrus fruits, exports from Italy, 1898–1908 ... 16–17
Orange, bitter, use as stock for lemon grafting, Italy ... 24
oil manufacture, Sicily ... 38, 42
peel, exports from Italy, 1898–1908 ... 18–19
Packing lemons, Italy, methods ... 31–32
Palermo district, Italy, lemon by-product industry ... 40–41
lemon export trade ... 10, 12–13, 20, 21, 41
growing ... 8, 9, 10, 20, 21, 23
Peel, citrus fruits, exports from Italy, 1898–1908 ... 18–19
lemon, exports from Italy, 1898–1908 ... 18–19
salting, Italy ... 43
orange, exports from Italy, 1898–1908 ... 18–19
Peeling lemons for oil extraction, methods and cost of labor, Italy ... 44
Picking lemons in Italy, methods ... 30–31
Ports, Italian, shipping lemons to United States ... 10, 12–13, 20
Potash, sulphate, fertilizer for lemon gardens, Italy ... 25
Powell, G. Harold, paper entitled "The Italian lemon industry" ... 7–33
Pruning, lemon trees, Italian method ... 25
Pulp, lemon, use in manufacture of citrate of lime, Italy ... 46, 49–50
Rainfall, annual, Sicily ... 27
Rock, ground, fertilizer for lemon gardens, Italy ... 25
Santa Teresa, lemon oil factories ... 38

Page.
Selling lemons in Italy, methods 28–29
Shipping lemons in Italy, seasons and methods 20, 31
Sicily, lemon by-product industry 8, 10, 15, 35–43
growing districts, description, seasons, etc 7–10, 20
industry, importance 7–10, 21, 35–43
oil manufacture, districts and factories, description 35–43
rainfall and temperature 27
Slag, fertilizer for lemon gardens, Italy 25
Soda, nitrate, as nitrogen source for lemon fertilizing 23, 25
Sorrentine peninsula, lemon growing 8, 20, 23, 27–28
Sorrento lemons, growing under trellises 28
Sponging process for extraction of lemon oil 46
Still, lemon oil, Italy, description 47
Syracuse district, Italy, lemon by-product industry 41–42
growing 8–9, 20
Tariff rates on lemons and their by-products entering United States 19
Terraces, lemon growing, Sorrentine peninsula 8, 28
Tillage of lemon gardens, Italy 25
Trees, citrus fruit, Italy, number, estimate 7
lemon, Italy, distribution and total number, 1898 10
planting distance 24
yield in different localities 24
Trellises, lemon groves, description 8, 27–28
United States, distribution of foreign lemons 13
districts from which Italian lemons are exported 12–13
imports of citrate of lime 16
lemon oil 17
lemons 11–12
methods of handling foreign lemons 13–15
rates of duty on lemons and their by-products 19
Verdelli lemons, description and methods of production 22–23

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